NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

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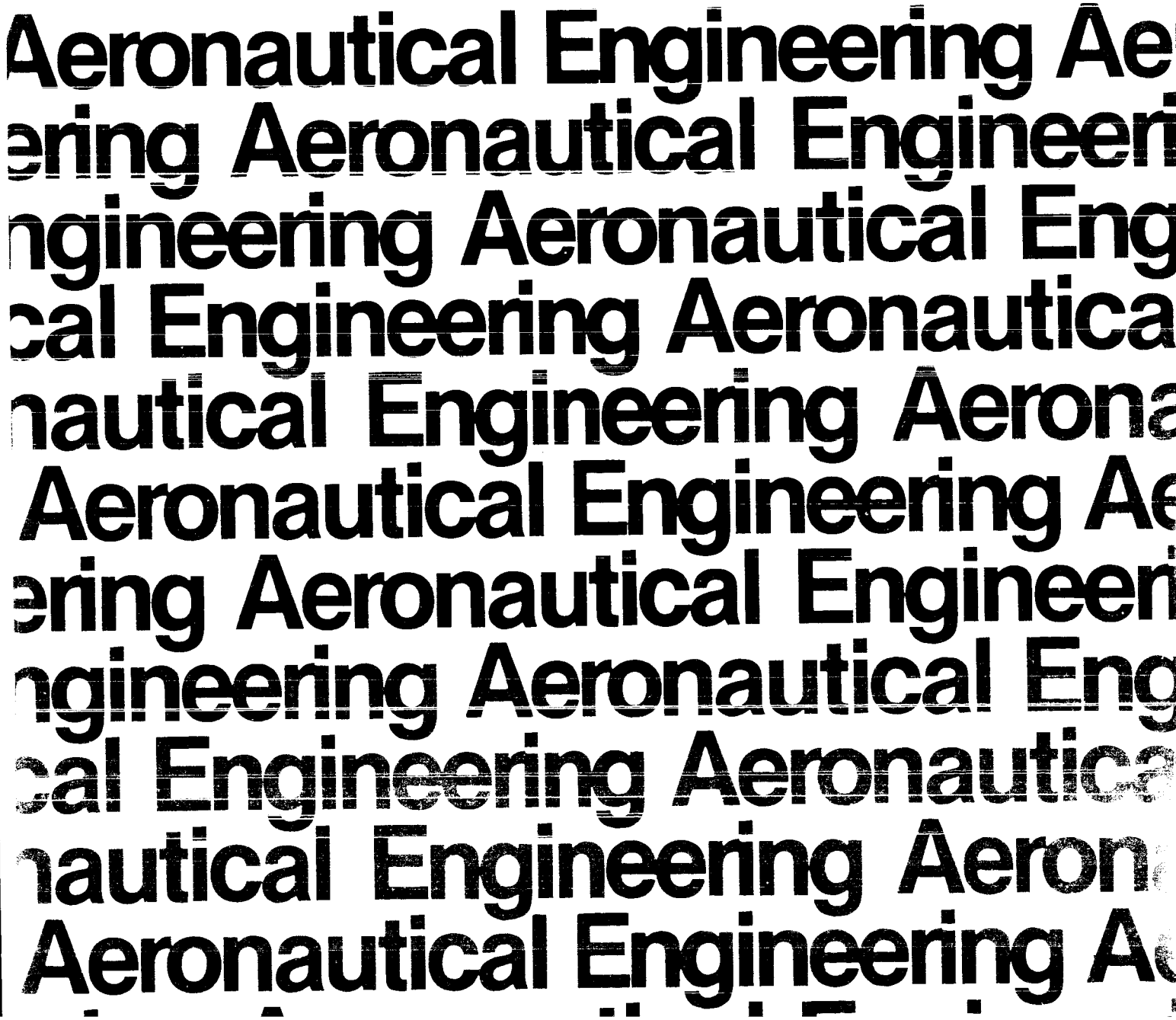

ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

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NASA SP-7037(239)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 239)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in April 1989 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

National Aeronautics and Space Administration
Office of Management
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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 454 reports, journal articles and other documents originally announced in April 1989 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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Category 06	**Aircraft Instrumentation** Includes cockpit and cabin display devices; and flight instruments.	**236**
Category 07	**Aircraft Propulsion and Power** Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.	**238**
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Category 09	**Research and Support Facilities (Air)** Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.	**248**
Category 10	**Astronautics** Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	**250**
Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**250**

Category 12 Engineering 253
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

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Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 262
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 265
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 267
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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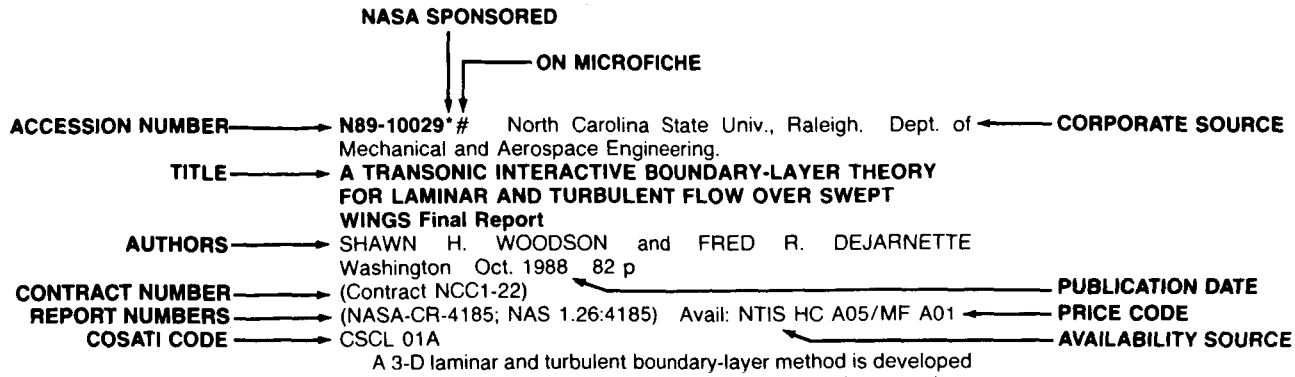
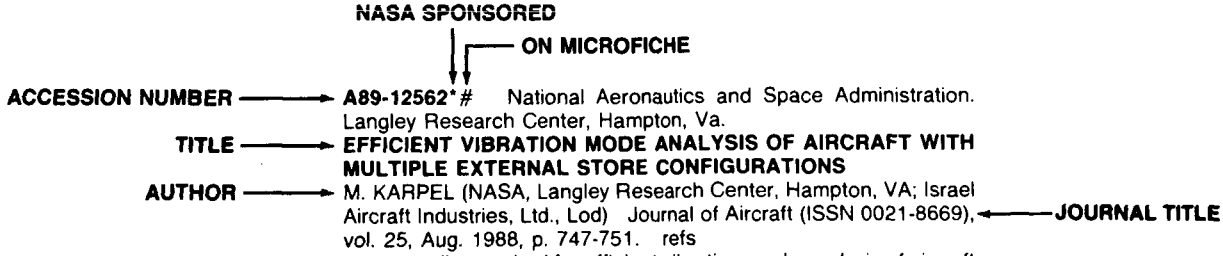
TYPICAL REPORT CITATION AND ABSTRACT



A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution. Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 239)

MAY 1989

01

AERONAUTICS (GENERAL)

A89-21021
AUTOMATION KEEPS JET ENGINES FLYING
ANDREW CULLISON Welding Journal (ISSN 0043-2296), vol. 67, Dec. 1988, p. 46-49.

The procedures used by a USAF center responsible for major jet engine overhaul and maintenance of jet engines taken from transport and fighter aircraft are discussed. Particular attention is given to the inspection facilities, the welding procedures and equipment, the new blade-facility operation, and thermal spraying operations. Special emphasis is placed on the role of automation in these operations. I.S.

A89-21409
CONCEPTS, PARAMETERS, AND SYMBOLS OF FLIGHT MECHANICS [CONCEPTS, GRANDEUR, ET SYMBOLES DE LA MECANIQUE DU VOL]
JEAN LACAINE (AAAF, Paris, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 132, 1988, p. 58-64. In French.

The standardization of terms, symbols, definitions, and parameters in flight mechanics is discussed, with special attention given to the specifications found in the International Standard Organization 1151 and Technical Committee 20 texts. Definitions are given for the parameters describing the energy of the aircraft with respect to the ground. Also considered is the standardization of the data provided by on-board accelerometers. R.R.

A89-21843#
AGILE AIRCRAFT - THE SEARCH FOR SUPERMANEUVERABILITY
BILL SIURU Mechanical Engineering (ISSN 0025-6501), vol. 110, Dec. 1988, p. 28-33.

A development status evaluation is presented for thrust-vectoring concepts applicable to military aircraft, of types ranging from assault/cargo vehicles for airborne troops to advanced fighter aircraft, in order to achieve either supermaneuverability for evasive tactics, or V/STOL operation, or both. The major technologies in question are forward-swept wings and thrust-vectoring nozzles for reaction-powered aircraft, and tiltable-rotor nacelles for turboshaft-powered ones, such as the V-22 Osprey and the 'Pointer' RPV. O.C.

A89-21846
AEROSPACE SYSTEMS AND TECHNOLOGY - THE ROLE OF THE RAE
G. G. POPE (Royal Aerospace Establishment, Farnborough, England) Aerospace (UK) (ISSN 0305-0831), vol. 15, Dec. 1988, p. 8-18.

The role of the RAE in developing aeronautical and space systems and technology is reviewed, including the history of the RAE and prospects for the organization's future. The major facilities of the RAE are discussed, including the engine test facility, wind tunnels, flight simulators, and weapon test ranges. The research program of the RAE is outlined, including the development of aircraft for night and all-weather operations, flight control systems for advanced short take-off and vertical landing aircraft, and computational fluid dynamics techniques. The development of airframe materials, vapor deposited alloys, and metal matrix composites are examined. Also, programs for weapon aimpoint refinement and systems assessment are considered. R.B.

A89-23003#
DETERMINATION OF ADMISSIBLE ATTRITION VALUES FOR HELICOPTER ASSEMBLY JOINTS IN STAND TESTS [OKRESLENIE DOPUSZCZALNYCH WARTOSCI ZUZYCIA RUCHOWEGO POLACZEN ZESPOLOW SMIGLOWCA W PROBACH STOISKOWYCH]
VLADIMIR V. OGORODOV (Vertoletnyi Zavod, Moscow, USSR) and RYSZARD BANEK (Panstwowe Zaklady Lotnicze, Swidnik, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, June 1988, p. 17, 18. In Polish.

A89-23349#
BK 117 - SURVIVING IN A DESPERATE MARKET PLACE
F. MUSMAN and W. REINL (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 15 p.

The development and marketing of the BK 117 helicopter are discussed. The introduction of new helicopter models and features to meet the demands of a changing market is considered. Various changes in the design and performance of the helicopter are examined, including payload size, take-off and hover performance, hot-day performance, temperature and altitude range, optional equipment, and lifetime improvement. R.B.

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A89-20948
CLASSROOM ANALYSIS AND DESIGN OF AXIAL FLOW COMPRESSORS USING A STREAMLINE ANALYSIS MODEL
R. D. FLACK (Virginia, University, Charlottesville) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 4, no. 3-4, 1987, p. 285-296. Research supported by the University of Virginia. refs

A simple analysis for the design of three-dimensional flows through multistage axial flow fans and compressors was developed for educational use in graduate and undergraduate courses in turbomachinery. It is a streamline analysis and the flow through annuli are analyzed using a simple control volume method. Vortex flow can be assumed or specified flow angles can be used to calculate the flowfield, pressures, and reactions. The solution is quick to converge and the method can be used for classroom design problems. Two examples of a modern turbofan engine

compressor design are used to demonstrate the technique: vortex flow and radially varying flow angles with radially varying efficiencies. Differences between the examples are discussed. Author

A89-20956#
EXPERIMENTAL INVESTIGATION OF WAKE AND BOUNDARY LAYER INTERACTION
E. G. TULAPURKARA, V. RAMJEE, and R. RAJASEKAR (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Feb. 1988, p. 45-53. refs

The mixing of a boundary layer on a flat plate with the wake of an NACA 0012 airfoil kept at a distance of about one boundary layer height is investigated experimentally for alpha = 0, 5, and 10 deg. The value of the skin friction coefficient (Cf) is low immediately behind the airfoil and it approaches the value of Cf for the undisturbed boundary layer except in the alpha = 0 deg case. The elimination of kinks in the velocity profiles is due to the fact that the wake defect becomes smaller downstream and the influence of the boundary layer grows upwards. K.K.

A89-21092#
PREDICTION OF SEPARATED FLOW PAST AIRFOIL USING VISCOUS-INVISCID INTERACTION TECHNIQUE
J. N. SORENSEN (Danmarks Tekniske Hojskole, Lyngby, Denmark) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1988, p. 1-11. refs

In the paper a viscous-inviscid interaction model, based on a quasi-simultaneous approach, is presented. The model consists of a finite-difference model for the boundary layer and a panel-method for the external inviscid flow. The interaction law is based on locally solving a part of the inviscid Neumann problem when marching through the solution of the boundary layer equations. Applying the model to solutions of separated flow past NACA 4412 and 4415 airfoils, it is compared to some experimental results. Author

A89-21095#
EXPERIMENTAL ANALYSIS OF TURBULENT SEPARATION ON AN OBLATE ELLIPSOID-CYLINDER
BRUNO CHANETZ and JEAN DELERY (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1988, p. 59-77. refs

An oblate half-ellipsoid obstacle extended by a large cylinder has been studied for three-dimensional separation characteristics in a turbulent flow field that was explored in detail by five-hole pressure probes and three-component LDA. At 30-deg incidence and 50 m/sec freestream velocity, two vortices emanate from separation lines near the obstacle's lateral edge; farther downstream, the vortices separate rapidly from the wall while strongly dilating. The results obtained furnish quantitative data on both the fluctuating motion velocity field and the spatial distribution of its kinetic energy. O.C.

A89-21153* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRANSONIC UNSTEADY AERODYNAMIC AND AEROELASTIC CALCULATIONS ABOUT AIRFOILS AND WINGS
PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) and GURU P. GURUSWAMY (Sterling Federal Systems, Inc., Palo Alto, CA) (Chinese Society of Theoretical and Applied Mechanics, International Conference on Computational Engineering Mechanics, Beijing, People's Republic of China, June 21-25, 1987) Computers and Structures (ISSN 0045-7949), vol. 30, no. 4, 1988, p. 929-936. refs

Recent advances in the numerical simulation of unsteady transonic flow around airfoils and wings are surveyed, with an emphasis on the treatment of aeroelastic effects. The fundamental physical principles involved are discussed, and the numerical implementation of the methods is considered. Typical results are presented in extensive graphs and diagrams and briefly characterized with reference to experimental data. T.K.

A89-21283
A LOW ORDER PANEL METHOD FOR THE CALCULATION OF VORTEX SHEET ROLL-UP AND WING-VORTEX INTERACTION
R. BEHR and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IN: Boundary elements X; Proceedings of the Tenth International Conference on Boundary Element Methods, Southampton, England, Sept. 6-9, 1988. Volume 2. Southampton, England/New York, Computational Mechanics Publications/Springer-Verlag, 1988, p. 259-273. refs

Vortex flows induced by separation on thin sharp-edged wings of arbitrary planform are investigated using a low-order panel method. Distributions of stepwise constant-strength doublet elements are used to represent the lifting-surface and free vortex sheets, and the numerical procedure is adapted to treat rolled-up discretized vortex sheets. Results for wings with and without leading-edge separation are presented in extensive graphs and discussed in detail, with reference to published experimental data. T.K.

A89-21284
PREDICTION OF AERODYNAMIC CHARACTERISTICS OF HIGH LIFT MULTI-ELEMENT AIRFOILS
C. DE NICOLA (Napoli, Universita, Naples, Italy), D. COIRO (Centro di Ricerche Aerospaziali, Naples, Italy), and V. LOSITO (Academia Aeronautica, Pozzuoli, Italy) IN: Boundary elements X; Proceedings of the Tenth International Conference on Boundary Element Methods, Southampton, England, Sept. 6-9, 1988. Volume 2. Southampton, England/New York, Computational Mechanics Publications/Springer-Verlag, 1988, p. 343-355. Research supported by MPI. refs

The fundamental principles and implementation of the MULTIM analysis code for high-lift airfoils (de Nicola et al., 1988) are discussed. MULTIM couples potential and inverse boundary-layer methods to characterize strong viscous-inviscid interactions via a semiinverse approach. The effectiveness of MULTIM for complex flows around highly loaded multicomponent airfoils with different gap-overlap combinations and extreme flap deflections is explored in trial computations, and results are presented in extensive graphs. The MULTIM predictions are shown to be generally more accurate than those of conventional finite-difference methods; the lift coefficients for a two-element airfoil are found to be within 1.5 percent of experimentally measured values up to stall conditions. T.K.

A89-21285* Old Dominion Univ., Norfolk, VA.
UNSTEADY TRANSONIC AIRFOIL COMPUTATION USING THE INTEGRAL SOLUTION OF FULL-POTENTIAL EQUATION
O. A. KANDIL and H. HU (Old Dominion University, Norfolk, VA) IN: Boundary elements X; Proceedings of the Tenth International Conference on Boundary Element Methods, Southampton, England, Sept. 6-9, 1988. Volume 2. Southampton, England/New York, Computational Mechanics Publications/Springer-Verlag, 1988, p. 357-371. refs
(Contract NAG1-648)

The shock-capturing integral-equation scheme developed by Kandil and Hu (1987) for the analysis of steady transonic flow over airfoils is extended to the unsteady case. The full potential formulation of the governing equations is reviewed; the solution method is outlined; and results for a NACA 0012 airfoil in forced pitching oscillation at Mach 0.755 are presented in extensive graphs and briefly characterized. The present technique is shown to require significantly less computation time than finite-difference or finite-volume methods, and to give shock-motion predictions in good agreement with those of an implicit finite-volume Euler solver; the surface-pressure peaks are slightly underpredicted. T.K.

A89-21515
EFFECT OF SMALL-SCALE TURBULENCE ON THE DEVELOPMENT OF COHERENT STRUCTURES IN A MIXING LAYER [O VOZDEISTVII MELKOMASSHTABNOI TURBULENTNOSTI NA RAZVITIE KOGERENTNYKH STRUKTUR V SLOE SMESHENIIA]

A. T. FEDORCHENKO (Moskovskii Fiziko-Tekhnicheskii Institut, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 302, no. 6, 1988, p. 1327-1332. In Russian. refs

A mathematical model is developed for the description of unsteady subsonic free flows, which are two-dimensional in the case of large-scale wave motion. The model includes a simultaneous analysis of the nonequilibrium development of small-scale turbulent pulsations. The proposed method is used to study the development of a turbulent mixing layer with harmonic excitation in the inlet section. Conditions are defined under which the growth of coherent structures in the flow is suppressed by small-scale pulsations. B.J.

A89-21565
CONSTRUCTION OF A WING PROFILE FROM VELOCITY DISTRIBUTIONS ON ITS SURFACE FOR TWO ANGLES OF ATTACK [POSTROENIE KRYLOVOGO PROFILIA PO RASPREDELENIIAM SKOROSTI NA EGO POVERKHNOSTI DLIA DVUKH UGLOV ATAKI]
A. M. ELIZAROV and D. A. FOKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 63-66. In Russian. refs

An exact solution is obtained for the problem of constructing an isolated wing profile in plane steady flow of a perfect incompressible fluid from velocity distributions specified on two parts of its surface (as a function of the arc abscissa) which characterize the flow for different angles of attack. The method of quasi-solutions for the inverse boundary value problems in aerohydrodynamics is used in order to satisfy the solvability conditions. Examples of numerical calculations are presented. V.L.

A89-21567
RECALCULATION OF PRESSURE DISTRIBUTION ON AN AIRFOIL [PERESCHET RASPREDELENIIA DAVLENIIA NA PROFILE]
O. P. SIDOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 70-74. In Russian.

Based on similarity theory, some generalized variables are obtained which are functionally related to the pressure coefficient. A simple procedure is then developed which makes it possible to recalculate pressure distributions from one angle of attack to another using simple expressions. Calculation results are presented for symmetric and nonsymmetric airfoils (NACA0012 and NACA23011). V.L.

A89-21580
NONLINEAR INTERACTIONS OF PERTURBATIONS DURING THE TURBULENT TRANSITION IN THE SEPARATION REGION OF A LAMINAR BOUNDARY LAYER [NELINEINYE VZAIMODEISTVIIA VOZMUSHCHENII PRI PEREKHODE K TURBULENTNOSTI V ZONE OTRYVA LAMINARNOGO POGRANICHNOGO SLOIA]
A. V. BOIKO, A. V. DOVGAL', and V. V. KOZLOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1988, p. 44-50. In Russian. refs

Experimental data are presented on the nonlinear evolution of perturbations during the turbulent transition in the local separation zone of a laminar boundary layer. It is shown that nonlinear processes take place, at least at the early stage, in two-dimensional flow. In this respect, the transition occurs in the same manner as in free boundary layers, in contrast to an attached boundary layer in which the nonlinear activity is associated with three-dimensional flow breakup. V.L.

A89-21581
TRANSITION TO TURBULENCE ON A WING IN FLIGHT AND IN A WIND TUNNEL AT THE SAME REYNOLDS NUMBERS [PEREKHOD K TURBULENTNOSTI NA KRYLE V POLETE I V AERODINAMICHESKOI TRUBE PRI ODINAKOVYKH CHISLAKH REINOL'DSA]
B. IU. ZANIN (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1988, p. 51-53. In Russian.

The effect of external perturbations on the structure of the transition in a boundary layer on the same wing section in flight and in a wind tunnel is investigated experimentally. It is shown that, despite the relatively high levels of external perturbations, the turbulent transition in both cases involves the evolution of an instability wave packet in the boundary layer. The mean frequencies of the packets in flight and in a wind tunnel are found to be similar. V.L.

A89-21582
QUASI-STATIONARY FLOW IN BLOWDOWN WIND TUNNELS [O KVAZISTATSIONARNOSTI POTOKA V IMPUL'SNYKH AERODINAMICHESKIKH TRUBAKH]
V. I. ZVEGINTSEV and A. P. SHASHKIN (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1988, p. 54-59. In Russian. refs

One-dimensional nonstationary flow in blowdown wind tunnels of different configurations is simulated numerically to test the nonstationary flow hypothesis. Determinations are made of the deviations of the principal flow parameters from the values calculated on the basis of the assumption of quasi-stationary flow for different ratios of the precombustion chamber volume and the critical nozzle cross section. It is shown that these deviations are negligible for the existing blowdown wind tunnels. V.L.

A89-21584
THE ROLE OF THE MECHANISM OF LOCAL SECONDARY INSTABILITY IN THE K-BREAKDOWN OF THE BOUNDARY LAYER [ROL' MEKHANIZMA LOKAL'NOI VTORICHNOI NEUSTOICHIVOSTI V K-RAZRUSHENII POGRANICHNOGO SLOIA]
V. I. BORODULIN and IU. S. KACHANOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1988, p. 65-77. In Russian. refs

The mechanisms underlying the formation of high-frequency spikes on the velocity fluctuation oscillograms of boundary layer breakdown in the K-regime are examined with reference to the results of low-turbulence subsonic wind tunnel tests. The experimental results support the concept of local high-frequency instability. It is shown, however, that this instability does not play an important role in the formation and doubling of spikes in the K-regime of the turbulent transition. V.L.

A89-21590
NONSTATIONARY FLOW PAST DELTA WINGS IN THE WAKE OF SHOCK WAVES [NESTATSIONARNOE OBTEKANIE TREUGOL'NYKH KRYL'EV POTOKOM ZA UDARNYMI VOLNAMI]
V. N. GOLUBKIN and V. V. NEGODA PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1988, p. 40-46. In Russian. refs

The problem of determining the nonstationary aerodynamic characteristics of delta wings interacting with a weak incident shock wave at supersonic flight velocities is analyzed using a linear formulation. By analogy with the problem of entry into an equivalent gust, explicit analytical expressions are obtained which describe the nonstationary forces and moments as a function of the principal parameters. V.L.

A89-21591
EXCITATION OF SECONDARY FLOW INSTABILITY WAVES IN A BOUNDARY LAYER ON A YAWED WING [VOZBUZHDENIE VOLN NEUSTOICHIVOSTI VTORICHNOGO TECHENIIA V POGRANICHNOM SLOE NA SKOL'ZIASHCHEM KRYLE]

A. V. FEDOROV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1988, p. 46-52. In Russian. refs

Excitation of secondary flow instability waves in a compressed boundary layer on a yawed wing is analyzed theoretically. The generation sources in this case are local forces on the flow resulting from the unevenness of the surface, its cooling or heating, and gas suction or injection through the porous surface. The efficiency of the excitation mechanism described here is estimated. V.L.

A89-21592
A STUDY OF A SWIRLING FLOW OF A VISCOUS GAS IN THE VICINITY OF THE STAGNATION LINE OF A BLUNT BODY [ISSLEDOVANIE ZAKRUCHENNOGO TECHENIIA VIAZKOGO GAZA V OKRESTNOSTI LINII TORMOZHENIIA ZATUPLENNOGO TELA]

S. V. PEIGIN PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1988, p. 52-58. In Russian. refs

The effect of body rotation and external swirling on viscous gas flow in the vicinity of the stagnation line of an axisymmetric blunt body with a porous surface is investigated using a model of parabolized Navier-Stokes equations. A numerical solution to the problem is obtained over a wide range of Reynolds number, injection parameters, and flow swirling. It is shown that the presence of a nonzero circumferential component of the gas velocity vector in the shock layer may produce qualitative changes in the flow characteristics. V.L.

A89-21923
NUMERICAL CALCULATION OF PROFILES CORRESPONDING TO GIVEN PRESSURE DISTRIBUTIONS

J. P. MEYER, E. H. MATHEWS, and G. P. VAN ZYL (Pretoria, University, Republic of South Africa) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 4, Nov.-Dec. 1988, p. 767-772. refs

A numerical procedure is proposed for calculating the profile corresponding to a given pressure distribution. The procedure employs a transformed version of the potential flow equation for the stream function, which makes the method very effective. Predicted profiles are verified against an analytical solution and against the profile of a NACA 0015 aerofoil. The measured pressure distribution on a calculated axisymmetrical profile is also found to compare favorably with its prescribed pressure distribution.
Author

A89-22003#
RESEARCH OF ONSET OF ROTATING STALL FOR DOUBLE BLADE ROWS

JIUNQIANG ZHU and ZHIWEI LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 218-223. In Chinese, with abstract in English. refs

With the help of an unsteady two-dimensional incompressible flow model, the inception criterion of rotating stall for double blade rows and a single blade row in an axial compressor is derived on the basis of a small disturbance stability theory. The calculation program is carried out. Good agreement between the theoretical and experimental values indicates that the analysis is believable. The influence of the axial distance between two blade rows on the loss and the whole flow field is analyzed. Both calculation and experiment indicate that the average flow angle at the inlet relative to blade row of double blade rows is larger than one of a single blade row when rotating stall appears. Author

A89-22004#
NUMERICAL ANALYSIS OF CASCADE VISCOUS FLOW USING THE NAVIER-STOKES EQUATIONS

XINHAI ZHOU and FANGYUAN ZHU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 230-235. In Chinese, with abstract in English. refs

An explicit, time-marching, numerical technique for the computation of cascade viscous flows through the solution of the complete Navier-Stokes equations is presented. An efficient multigrid algorithm for solving the Euler equations is successfully used in the solution procedure of the Navier-Stokes equations. A separated, laminar flow in compressor cascade and viscous flow in transonic turbine cascade are computed and the numerical results are compared with experimental data to illustrate the accuracy and efficiency of the technique. Author

A89-22005#
NUMERICAL SIMULATION OF REAL FLOW FIELD WITH TRANSONIC CASCADES

XIN YUAN and ZIKANG JIANG (Tsinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 236-238. In Chinese, with abstract in English. refs

A fully implicit finite difference code has been specified to solve Navier-Stokes equations with two dimensional transonic cascade flow fields. Numerical computations have been made with a two-layer algebraic eddy viscosity model. Computed results show good agreement with experiment data. A local separated region in the cascade is found. The method has actual significance for researching real and separated flow with transonic cascades.
Author

A89-22006#
A SIMPLE METHOD FOR SOLVING DIRECT PROBLEMS OF 3-D FLOW IN AXIAL TURBOMACHINERY

XIAOLU ZHAO (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 239-241. In Chinese, with abstract in English. refs

The Mean Stream Surface Method (MSSM) employing a Taylor series expansion across the passage of turbomachines has been developed to solve direct and hybrid problems of full three-dimensional flow in subsonic turbomachines of axial flow type. Based on the original indirect procedure, analysis and hybrid problems can be solved by iteration between S(2m) flow calculation and the MSSM expansion. Two computer programs for analysis and design problems have been developed to meet different specifying conditions. Author

A89-22029#
AN EXPERIMENTAL INVESTIGATION ON THE FLUTTER OF THE CASCADE OF TURBOMACHINERY IN THE TRANSONIC FLOW

YOJI HANAMURA and KAZUO YAMAGUCHI (Tokyo, University, Japan) Tokyo, University, Faculty of Engineering, Journal, Series B (ISSN 0563-7937), vol. 39, March 1988, p. 311-338.

A Freon gas wind tunnel is used to study the aerodynamic interblade interaction of the cascaded blade row in transonic flow. Experiments are carried out on a turbine cascade with a relatively low turning angle but high stagger angle, and on a turbine cascade with a high turning angle but zero inlet angle. The advantages of the one-blade oscillation method are discussed. K.K.

A89-22231
VISUALIZATION OF HYPERSONIC FLOWS THROUGH MAGNESIUM VAPOR COMBUSTION [VIZUALIZATSIIA GIPERZVUKOVYKH TECHENII PRI GORENII PAROV MAGNIIA]

V. I. ALFEROV, E. A. BOZHKOVA, L. M. DMITRIEV, and A. A. SHINELEV Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 24, Sept.-Oct. 1988, p. 57-60. In Russian. refs

A method for visualizing hypersonic flows is described whereby a magnesium vapor jet is injected into the flow and the luminescence resulting from the combustion of the vapor makes it possible to visualize the flow patterns. Since the oxidation reaction rate is strongly dependent on gas density, the luminescence is sensitive to pressure gradients. It is also suggested that the dependence of luminescence on the flow parameters can be used in the analysis of physicochemical processes during the combustion of metal vapors. V.L.

A89-22239
EXPERIMENTAL INVESTIGATION OF THE AERODYNAMICS OF A DISK-CYLINDER SYSTEM [EKSPERIMENTAL'NOE ISSLEDOVANIE AERODINAMIKI SISTEMY DISK-TSILINDR]
A. I. BURAVTSEV, M. G. EFREMOV, E. F. ZHIGALKO, and L. V. NAZARENKO Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Aug. 1988, p. 49-52. In Russian.

The aerodynamic characteristics of an axisymmetric disk-cylinder combination (an example of a body with separated flow at the leading edge) were studied in the Leningrad University wind tunnel facility. The dependence of drag on the geometric parameters is evaluated. Results of normal force and momentum measurements at nonzero angles of attack are presented. B.J.

A89-22240
EFFECT OF A VORTEX WAKE ON THE PERTURBED MOTION OF AN ELASTIC AIRFOIL [VLIIANIE VIKHREVOGO SLEDA NA VOZMUSHCHENNOE DVIZHENIE UPRUGOGO PROFILIA]
B. A. ERSHOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Aug. 1988, p. 57-61. In Russian.

The two-dimensional problem of the perturbed motion of a thin wing in an incompressible subsonic flow is reduced to a system of two integrodifferential equations with partial derivatives with respect to the intensity of the vortex wake and the wing deformation. The solution is given in the form of the Laplace transformation of the wing deformations. B.J.

A89-22245
MODEL PROBLEM OF THE HYPERSONIC RELAXING-GAS FLOW PAST BODIES [MODEL'NAIA ZADACHA GIPERZVUKOVOGO OBTEKANIIA TEL RELAKSIRUIUSHCHIM GAZOM]
S. A. IVANOV and V. N. ENGEL'GART Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Aug. 1988, p. 99, 100. In Russian.

An asymptotic solution to a model problem of the hypersonic relaxing-gas flow past bodies with respect to a small parameter (the effective adiabatic index) is obtained with an accuracy to the second approximation. It is shown that the relaxation effect appears beginning with terms of second order with respect to the small parameter. B.J.

A89-22276*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES SOLUTIONS FOR MIXED COMPRESSION AXISYMMETRIC INLET FLOW WITH TERMINAL SHOCK
W. J. CHYU, T. KAWAMURA, and D. P. BENCZE (NASA, Ames Research Center, Moffett Field, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 4, 5. Abridged. Previously cited in issue 09, p. 1191, Accession no. A87-24932.

A89-22295#
CORRELATION OF NOZZLE PERFORMANCE DEGRADATION DUE TO SWIRL
J. C. DUTTON (Illinois, University, Urbana) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 126-128. refs
(Contract F49620-82-C-0035; F33615-81-C-2078)

An attempt is made to identify a 'universal' swirl number, and to represent correlations for the mass flow and thrust performance parameters of supersonic propulsion nozzles with swirling flow. This parameter ideally collapses the discharge coefficient, thrust efficiency, and specific impulse efficiency curves for various nozzle geometries and tangential velocity profiles onto single universal curves when used as the independent variable. O.C.

A89-22328
COMPUTATION OF SUBSONIC AND TRANSONIC HELICOPTER ROTOR FLOW USING EULER EQUATIONS
E. KRAEMER, J. HERTEL, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, Federal Republic of Germany) Vertica (ISSN 0360-5450), vol. 12, no. 3, 1988, p. 279-291. Research supported by BMFT. refs

A procedure for the computation of transonic steady and unsteady flow around helicopter rotors is presented. The algorithm is based on the Euler equations and allows the computation of anisotropic rotational flow and thus an implicitly accurate calculation of shocks. In addition, the capturing of the rotor wake and the tip vortex is provided for arbitrary tip shapes. The code for the computation of steady, fully 3-D rotor flow is derived from the EUFLEX procedure originated by A. Eberle, that has successfully been applied to a lot of fixed wing configurations up to now. A finite-volume scheme based on the method of characteristic flux averaging solves the Euler equations formulated in the conservation form. The discretization of the flow field is carried out in two different manners concerning the grid topology and the size of the physical domain. Calculations are presented for a non-lifting case and for a helicopter rotor in hover. The comparisons of the method in its present stage show good agreement with experimental data. Author

A89-22330* Sterling Software, Palo Alto, CA.
EULER SOLUTION OF MULTIBLADE ROTOR FLOW
C. L. CHEN, S. X. YING (Sterling Software, Palo Alto, CA), and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 12, no. 3, 1988, p. 303-313. Previously announced in STAR as N88-14322. refs

A numerical method for solving the Euler equations for multiblade rotors has been developed and some preliminary results reported. The numerical scheme is a combination of several recent methods and algorithm improvements, adapted to the particular requirements of rotor-body interactions. A cylindrical basic grid has been used to study conventional multiblade helicopter rotors. Test calculations have been made for two- and six-blade rotors in hover and for a two-blade rotor in forward flight, under transonic tip conditions but without lift. The results show good agreement with experimental data. Author

A89-22333
A NEW TRANSFORMATION FOR COMPUTING HYPERGEOMETRIC SERIES AND THE EXACT EVALUATION OF THE TRANSONIC ADIABATIC FLOW OVER A SMOOTH BUMP
G. CHIOCCHIA (Torino, Politecnico, Turin, Italy) and B. GABUTTI (Torino, Universita, Turin, Italy) (Symposium on Physical Aspects of Numerical Gas Dynamics, Farmingdale, NY, Aug. 12, 13, 1987) Computers and Fluids (ISSN 0045-7930), vol. 17, no. 1, 1989, p. 13-23. refs

The evaluation of the hypergeometric functions has always been a main problem in the computation of isentropic compressible flows by the hodograph method, particularly because of the ill-conditioning of the series involved. In this work a new approach based on a generalized Euler transformation is established, and its efficiency is verified by computing the exact transonic flow over a smooth bump. Author

A89-22337* Cincinnati Univ., OH.
TRANSONIC FLOW SOLUTIONS USING A COMPOSITE VELOCITY PROCEDURE FOR POTENTIAL, EULER AND RNS EQUATIONS
R. E. GORDNIER and S. G. RUBIN (Cincinnati, University, OH) (Symposium on Physical Aspects of Numerical Gas Dynamics, Farmingdale, NY, Aug. 12, 13, 1987) Computers and Fluids (ISSN 0045-7930), vol. 17, no. 1, 1989, p. 85-98. Previously announced in STAR as N87-25995. refs
(Contract NAG1-8; F49620-85-C-0027)

Solutions for transonic viscous and inviscid flows using a composite velocity procedure are presented. The velocity components of the compressible flow equations are written in terms of a multiplicative composite consisting of a viscous or rotational velocity and an inviscid, irrotational, potential-like function. This provides for an efficient solution procedure that is locally

representative of both asymptotic inviscid and boundary layer theories. A modified conservative form of the axial momentum equation that is required to obtain rotational solutions in the inviscid region is presented and a combined conservation/nonconservation form is applied for evaluation of the reduced Navier-Stokes (RNS), Euler and potential equations. A variety of results is presented and the effects of the approximations on entropy production, shock capturing, and viscous interaction are discussed. Author

A89-22339
APPLICATION OF LAMBDA-DIFFERENCING SCHEMES TO HYPERSONIC INVISCID FLOWS
DARRYL W. HALL (Science Applications International Corp., Wayne, PA) (Symposium on Physical Aspects of Numerical Gas Dynamics, Farmingdale, NY, Aug. 12, 13, 1987) Computers and Fluids (ISSN 0045-7930), vol. 17, no. 1, 1989, p. 113-126. refs

The application of lambda differencing algorithms to three-dimensional inviscid hypersonic flows is illustrated for both time-dependent and steady problems. Specific examples are provided to demonstrate the advantages of this approach relative to noncharacteristic-based differencing schemes for realistic problems. Using body-oriented computational coordinate systems based on conformal-mapping grid-generation techniques, the algorithm is shown to produce improved results for bodies with curvature discontinuities or regions of high curvature. Author

A89-22342
COMPLEX SHOCK PATTERNS AND VORTICES IN INVISCID SUPERSONIC FLOWS
F. MARCONI (Grumman Corporate Research Center, Bethpage, NY) (Symposium on Physical Aspects of Numerical Gas Dynamics, Farmingdale, NY, Aug. 12, 13, 1987) Computers and Fluids (ISSN 0045-7930), vol. 17, no. 1, 1989, p. 151-163. refs

Moretti's (1974) computational procedures are applied to an investigation of fluid physics. Specifically, the effects of shock vorticity on the supersonic inviscid flow about circular-cross-section cones is considered. While the Euler equations are solved so that no viscous effects are included, the shock vorticity can cause flow separation and vortex formation. The interaction of these vortices and shocks produces a number of interesting phenomena, which are discussed in detail. Author

A89-22346
TRANSONIC FLOW ABOUT A CIRCULAR CYLINDER
M. PANDOLFI (Torino, Politecnico, Turin, Italy) and F. LAROCCA (Fiat Aviazione S.p.A., Turin, Italy) (Symposium on Physical Aspects of Numerical Gas Dynamics, Farmingdale, NY, Aug. 12, 13, 1987) Computers and Fluids (ISSN 0045-7930), vol. 17, no. 1, 1989, p. 205-220. refs

The inviscid transonic flow about a circular cylinder is investigated analytically, applying an upwind hybrid finite-difference method to the numerical solution of the Euler equations. The hybrid scheme combines the lambda procedure of Moretti (1979) with a flux-difference splitting method. Results from simulations of flow around both half and full cylinders are presented in extensive graphs and diagrams and discussed in detail. For the half cylinder, the separation point is behind the cylinder, and a small but significant perfectly periodic unsteady condition arises at freestream Mach numbers of 0.5 and especially 0.6. The full-cylinder case is characterized by asymmetric unsteady periodic flows with eddy shedding behind the cylinder. T.K.

A89-22355*# Vigyan Research Associates, Inc., Hampton, VA.
HIGH-RESOLUTION UPWIND SCHEMES FOR THE THREE-DIMENSIONAL INCOMPRESSIBLE NAVIER-STOKES EQUATIONS
PETER M. HARTWICH and CHUNG-HAO HSU (Vigyan Research Associates, Inc., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1321-1328. Previously cited in issue 18, p. 2811, Accession no. A87-42650. refs
(Contract NAS1-17919)

A89-22357#
UNSTEADY FLOW IN A SUPERCRITICAL SUPERSONIC DIFFUSER
R. T. BIEDRON and T. C. ADAMSON, JR. (Michigan, University, Ann Arbor) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1336-1345. refs
(Contract AF-AFOSR-84-0327)
(AIAA PAPER 87-0162)

Unsteady flow through a two-dimensional supersonic diffuser with a normal shock wave is analyzed using asymptotic methods. Two time regimes are considered, the first corresponding to fundamentally unsteady flow, the second to quasisteady flow; a unified solution containing both time regimes is also presented. An ordinary differential equation describing the shock-wave motion is found. Examples show the motion of a shock wave resulting from impressed back pressure oscillations and from changes in flow area due to a separated flow region. For cases involving separated flows, additional numerical solutions are required to obtain typical wall shapes as functions of time. Unstarts and self-sustained oscillations are considered. Author

A89-22358*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FINITE-VOLUME CALCULATION OF INVISCID TRANSONIC AIRFOIL-VORTEX INTERACTION
MURALI DAMODARAN (NASA, Ames Research Center, Moffett Field, CA; Cornell University, Ithaca, NY) and DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1346-1353. Previously cited in issue 18, p. 2804, Accession no. A87-42338. refs
(Contract NAG2-218)

A89-22359*# Iowa State Univ. of Science and Technology, Ames.
SIMULTANEOUS VISCOUS-INVISCID INTERACTION CALCULATION PROCEDURE FOR TRANSONIC TURBULENT FLOWS
D. LEE and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) (Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers, p. 578-586) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1354-1362. Previously cited in issue 18, p. 2801, Accession no. A87-42101. refs
(Contract NAG2-152)

A89-22368#
SMOKE WIRE VISUALIZATION OF UNSTEADY SEPARATION OVER AN OSCILLATING AIRFOIL
JONG SEONG KIM and SEUNG O. PARK (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1408-1410. refs

A flow visualization examination is conducted for the separation phenomenon in an airfoil whose pitch oscillates with small amplitude. Attention is given to the chronology of events that occur during a period of oscillation; the unsteady separation observed in the visualization study is interpreted in light of unsteady boundary layer-separation theory. Unsteady separation occurred as the front of the reversed flow region reached its uppermost position. O.C.

A89-22576* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SEPARATION-BUBBLE FLOW SOLUTION USING EULER/NAVIER-STOKES ZONAL APPROACH WITH DOWNSTREAM COMPATIBILITY CONDITIONS
C. H. LIU (NASA, Langley Research Center, Hampton, VA), T. C. WONG, and O. A. KANDIL (Old Dominion University, Norfolk, VA) Journal of Scientific Computing (ISSN 0885-7474), vol. 3, June 1988, p. 121-137. refs
(Contract NAS1-17993)

The two-dimensional flow over a blunt leading-edge plate is simulated on the basis of an Euler/Navier-Stokes zonal scheme.

The scheme uses an implicit upwind finite-volume scheme, which is based on the van Leer flux-vector splitting. It is shown that the Euler/Navier-Stokes zonal scheme with downstream boundary-layer compatibility conditions is accurate and efficient. K.K.

A89-22626#
REARRANGEMENT OF VORTEX STREET IN THE WAKE BEHIND A TWO-DIMENSIONAL BODY
MUNESHIGE OKUDE and TATSUYA MATSUI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 418, 1988, p. 498-504. In Japanese, with abstract in English. refs

The vortex streets in the wake behind a two-dimensional body were studied experimentally in a wind tunnel at the lower Reynolds number than the critical value. There were the regular mode at lower Reynolds numbers than the critical value and the irregular mode at the higher Reynolds numbers of vortex shedding for three types of two-dimensional bodies. The streamwise variation of the velocity fluctuations was similar to that in the wake of a circular cylinder. The dimensionless frequency was proportional to the Reynolds number both in the primary and the secondary vortex street. Author

A89-22627#
THE INFLUENCE ON TOTAL PERFORMANCE FOR VARYING THE STATOR SETTING ANGLE OF MULTI-STAGE AXIAL COMPRESSOR
YOH KAKEHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 418, 1988, p. 505-511. In Japanese, with abstract in English. refs

In the development phase of an aircraft gasturbine, the required performances of the gasturbine components are decided after general consideration of the engine total performance. For accomplishing the required performance, the tedious and expensive works of design for modification, production and tests were laboriously repeated. This paper introduces the practical and useful method describing the relation between component performances of the compressor and the combination of the stator setting angle analyzing by statistical methods based on the experimental data. Author

A89-22735*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYSIS OF ARTIFICIAL VISCOSITY EFFECTS ON REACTING FLOWS USING A SPECTRAL MULTIDOMAIN TECHNIQUE
MICHELE G. MACARAEG, CRAIG L. STREETT (NASA, Langley Research Center, Hampton, VA), and M. Y. HUSSAINI (Institute for Computer Applications in Science and Engineering, Hampton, VA) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 3, Jan. 1989, p. 13-18. Previously announced in STAR as N87-22632. refs

Standard techniques used to model chemically-reacting flows require an artificial viscosity for stability in the presence of strong shocks. The resulting shock is smeared over at least three computational cells, so that the thickness of the shock is dictated by the structure of the overall mesh and not the shock physics. A gas passing through a strong shock is thrown into a nonequilibrium state and subsequently relaxes down over some finite distance to an equilibrium end state. The artificial smearing of the shock envelops this relaxation zone which causes the chemical kinetics of the flow to be altered. A method is presented which can investigate these issues by following the chemical kinetics and flow kinetics of a gas passing through a fully resolved shock wave at hypersonic Mach numbers. A nonequilibrium chemistry model for air is incorporated into a spectral multidomain Navier-Stokes solution method. Since no artificial viscosity is needed for stability of the multidomain technique, the precise effect of this artifice on the chemical kinetics and relevant flow features can be determined. Author

A89-22757#
THE NUMERICAL SIMULATION OF UNSTEADY FLOWS AROUND PROFILES [NUMERISCHE SIMULATION INSTATIONAERER PROFILUMSTROEMUNGEN]
K. DORTMANN Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 28, 29. In German.

Results from the author's recent analytical investigations of unsteady viscous compressible flow around wing profiles are briefly summarized and illustrated with graphs. In these numerical simulations, the Navier-Stokes equations in their divergence form are solved using a five-step Runge-Kutta scheme implemented on a vector computer. Starting from the steady solution for a NACA 4412 profile at zero angle of attack, Reynolds number 10,000, and Mach 0.2, the upstream flow velocity was varied between 0.5 and 2 times the initial value, and the changes in the flow structure were observed. T.K.

A89-22758#
COMPUTATION OF FLOWS AROUND SUPERCRITICAL PROFILES [BERECHNUNG SUPERKRITISCHER PROFILUMSTROEMUNGEN]
M. BREUER Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 30, 31. In German. refs

Results from the author's recent theoretical studies of supercritical flows are briefly summarized. The transonic flow around a CAST 7 supercritical wing profile was simulated numerically, applying the laminar-flow algorithm of Schroeder and Haenel (1987) and the turbulence model of Baldwin and Lomax (1978) to solve the Navier-Stokes equations. Results for freestream Mach number 0.76 and Reynolds number 1.5 x 10 to the 6th are presented in graphs and compared with published experimental data; good agreement is demonstrated. T.K.

A89-22760#
TRAILING-EDGE FLOW IN AN UNSTEADY AMBIENT FLOW [HINTERKANTENSTROEMUNG IN INSTATIONAERER ANSTROEMUNG]
B. SCHWEITZER Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 36, 37. In German. refs

Results from the author's recent experimental studies of unsteady trailing-edge flows are briefly summarized and illustrated with graphs and photographs. The effects of a time-variable upstream flow velocity on the flow around NACA 4409, 4412, and 4424 profiles at constant angles of attack and Reynolds numbers 1500-20,000 were investigated in water-tank, water-tunnel, and wind-tunnel experiments, with a focus on the unsteady pressure distribution and the time evolution of the phase-averaged boundary-layer profiles in the transition zone. T.K.

A89-22761#
FLOW VISUALIZATION FOR LAMINAR PROFILES [STROEMUNGSSICHTBARMACHUNG AN LAMINARPROFILEN]
P. GUNTERMANN Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 38, 39. In German.

Techniques for visualizing laminar flows on wing profiles are described and demonstrated, summarizing the results of the author's recent water-tunnel experiments. Low-Reynolds-number flows around NACA 663018 and FX 63-137 profiles were visualized using a light-slit method; sample images and graphs of typical data are shown. It was found that the laminar separation point on the upper surface was shifted upwind as the angle of attack was increased and downwind as the Reynolds number was increased. T.K.

A89-22762#
EXPERIMENTAL INVESTIGATIONS IN THE TRANSONIC AND SUPERSONIC WIND TUNNEL [EXPERIMENTELLE UNTERSUCHUNGEN IM TRANSONIC- UND UEBERSCHALLWINDKANAL]

H.-J. ROMBERG Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 40, 41. In German. refs

Recent experiments performed in the adaptive-wall transonic/supersonic wind tunnel at the Aerodynamisches Institut are surveyed and illustrated with graphs. The tunnel features a 40 x 40-cm test section and velocities continuously variable between Mach 0.3 and Mach 4.0. Topics discussed include the methods used to compute fictive external flows (to permit exact adjustment of the wall configuration) and measurements on an Ariane 5 model at Mach 2. T.K.

A89-22763#
VORTEX STREET IN THE WAKE OF A FLAT PLATE IN LONGITUDINAL FLOW [WIRBELSTRASSE IM NACHLAUF EINER LAENGS ANGESTROEMTEN EBENEN PLATTE]
W. ALTHAUS Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 29, 1988, p. 42, 43. In German.

Results from the author's recent experimental studies of turbulent wake flows are summarized. The wake of a flat plate is investigated at subsonic and supersonic velocities in the 40 x 40-cm and 15 x 15-cm wind tunnels of the Aerodynamisches Institut. The formation and evolution of a vortex street are followed using differential interferometry, laser schlieren techniques, holographic interferometry, and two-component LDA; typical results are presented in graphs and photographs and briefly characterized. T.K.

A89-22801
2-D TRANSONIC FLOW WITH ENERGY SUPPLY BY HOMOGENEOUS CONDENSATION - ONSET CONDITION AND 2-D STRUCTURE OF STEADY LAVAL NOZZLE FLOW
G. SCHNERR (Karlsruhe, Universitaet, Federal Republic of Germany) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 3, Dec. 1988 (1989), p. 145-156. Research supported by the Klein, Schanzlin und Becker Stiftung and DFG. refs

A generalized form of the similarity law for the condensation onset Mach number of water vapor in air in the transonic and supersonic range for water vapor flow in moist air is derived from well known basic approaches for supersonic nozzles. These statements are confirmed by extensive experimental investigations in Laval nozzles, as well as by results of other authors and computations on the basis of the Euler equation linked with the classical theory of nucleation and droplet growth. In this experimental research priority is given to the qualitative description of the two-dimensional condensation processes, and their effects in transonic flows in nozzles of different geometrical configration (e.g., slightly or well curved). A quantitative discussion of two-dimensional structures in condensation regions requires the introduction of a characteristic angle along streamlines. It is then directly possible to describe the different types of compression disturbances in supersonic flows with heat addition. Author

A89-22805* Colorado Univ., Boulder.
TOWARD DYNAMIC SEPARATION WITHOUT DYNAMIC STALL
P. FREYMUTH, S. JACKSON, and W. BANK (Colorado, University, Boulder) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 3, Dec. 1988 (1989), p. 187-196. refs
(Contract F49620-84-C-0065; NAG1-769)

The concept of vorticity separation without dynamic stall is illustrated by flow visualization. A small airfoil with a rotating nose, originally built for the demonstration of static stall control, was placed in a wind tunnel and dynamically pitched. The flow around the airfoil during pitch was successfully visualized and filmed. It exhibited dynamic trailing edge separation of vorticity without leading edge dynamic stall. Diagrams of the airfoil assembly are included. I.S.

A89-22809*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISCOUS TRANSONIC AIRFOIL WORKSHOP COMPENDIUM OF RESULTS
TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1073-1087. Previously cited in issue 18, p. 2810, Accession no. A87-42471. refs

A89-22812#
NAVIER-STOKES CALCULATIONS OF TRANSONIC VISCOUS FLOW ABOUT WING/BODY CONFIGURATIONS
J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1106-1112. Research supported by the McDonnell Douglas Independent Research and Development Program. Previously cited in issue 18, p. 2803, Accession no. A87-42315. refs

A89-22813#
VISUALIZATION AND MEASUREMENT OF THE TIP VORTEX CORE OF A ROTOR BLADE IN HOVER
T. L. THOMPSON (McDonnell Douglas Helicopter Co., Mesa, AZ), N. M. KOMERATH, and R. B. GRAY (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1113-1121. refs
(Contract DAAG29-82-K-0094)

Detailed measurements with a laser Doppler velocimeter (LDV) have been performed in the tip region and in the tip vortex core of a single-bladed model rotor in hover. The testing was conducted at a rotor tip speed of 32 m/s, a Reynolds number of 269,000, and at two values of the rotor thrust coefficient, 0.0022 and 0.0057. Strobed laser sheet flow visualization was used to verify the steadiness of the tip vortex trajectory in the near wake and quantify the vortex trajectory to guide LDV surveys of the vortex core. A remotely aligned off-axis receiving optics system enabled measurement of vortex core velocity profiles at large focal lengths. The core self-induced velocity components extracted from these data are presented. The data exhibit evidence of secondary structure even inside the rotational core of the vortex. The axial velocity profile along the core has been extracted and presented in the wake of a spinning rotor. It is seen that the tip vortex of a rotating blade differs considerably in structure from a fixed-wing vortex. Author

A89-22814#
IMPROVED THIN-AIRFOIL THEORY
M. F. ZEDAN and K. ABU-ABDOU (King Saud University, Riyadh, Saudi Arabia) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1122-1128. Research supported by King Saud University. refs

The classical thin-airfoil theory has been reconsidered with the purpose of improving its accuracy and extending its range of applicability. Two improvements were implemented. First, the effect of profile thickness on the overall aerodynamic parameters C(L) and C(M) has been allowed for. Second, a simple procedure has been developed to determine the coefficients in the series expansions of the vortex and source distributions by directly using the given profile coordinates instead of the less accurate numerically determined slopes. Over a wide range of Karman-Trefftz airfoil geometries and angles of attack with only five control points, it was found that the accuracy of the present method is substantially improved and its validity is extended to thickness ratios as high as 16 percent. Surprisingly, except for very limited situations, the accuracy of the method was found to be comparable to or even better than that of the Hess-Smith (1967) method using 100 panels. Author

A89-22825
THE TURBULENT NEAR WAKE AT A SHARP TRAILING EDGE
E. A. BOGUCZ (Syracuse University, NY) and J. D. A. WALKER (Lehigh University, Bethlehem, PA) Journal of Fluid Mechanics

(ISSN 0022-1120), vol. 196, Nov. 1988, p. 555-584. Research supported by USAF. refs
(Contract NSF MEA-80-16929)

The problem of a turbulent boundary layer that evolves into a wake flow at the sharp trailing edge of a thin flat plate is considered; the formal structure of the near-wake flow is investigated using matched expansions in the limit of infinite Reynolds number. The symmetric turbulent near wake is shown to develop a two-layer structure which is independent of turbulence model. The general asymptotic analysis shows that a thin layer at the wake centerline grows linearly with distance from the trailing edge while the centerline velocity varies logarithmically in a manner that is supported strongly by experimental measurements. The relatively thick outer layer of the near-wake flow is undisturbed by the evolution of the inner layer to leading order. An additional region near the trailing edge is required to resolve a nonuniformity in transverse velocity. The general asymptotic results are used to guide the development of a zonal turbulence model for the near wake in the form of a simple eddy viscosity formula. Analytic profiles for velocity and Reynolds stress are obtained for the near-wake region; these profiles are shown to provide accurate representations of available near-wake experimental data. Author

A89-22875#
A STREAM FUNCTION-VORTICITY-PRESSURE POTENTIAL FORMULATION FOR SOLUTION OF THE STEADY EULER EQUATION

Z. FANG and A. J. SABER (Concordia University, Montreal, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Dec. 1988, p. 239-247. refs
(Contract NSERC-A-4202)

A new variable is proposed to couple the stream function-vorticity formulation of the steady Euler equations. The development of the variable, designated the pressure potential, and its employment in a stream function-vorticity formulation of the steady Euler equations are shown. The partial differential equation relating the new variable and other variables of the flow field is derived from the steady Euler equations. Boundary conditions for this variable are very straightforward to implement when the finite element weighted residual method is employed. With this formulation, the difficulty encountered when stream function formulation is applied to transonic internal flow calculations is overcome easily. This formulation is also applied to external flows. The solution procedure for this variable is very similar to that for velocity potential. However, in contrast to the velocity potential, rotational effects are taken into account. To achieve this purpose, the stream function and vorticity method is extended to solve compressible inviscid flow problems in this work. Two procedures to handle the vorticity transport equation are discussed. First, the vorticity transport equation is solved simultaneously with the stream function equation. Second, the second order vorticity transport equation is solved. In the latter case, an auxiliary boundary condition must be satisfied as the compensation for the increase of partial differential equation order. Author

A89-23120#
LASER VELOCIMETER MEASUREMENTS IN A MODEL PROPELLER FLOWFIELD

J. LEPICOVSKY (Avco Lycoming Textron, Stratford, CT) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 110, Dec. 1988, p. 350-354. Research supported by Lockheed-Georgia Co. refs

The objective of this work was to demonstrate the usability of a laser velocimeter data acquisition and reduction techniques for ensemble-averaged velocity measurements near and between rotating propeller or fan blades. A relatively simple experiment was set up to measure the flowfield of a two-bladed model propeller operating at static (non-flight) conditions to verify the data reduction procedures. The mean velocity and ensemble-averaged blade-to-blade velocity distributions were acquired. The experimental results, plotted in a novel concise form, showed separated and reversed flow regions on a rotating static propeller. The flowfield distortion along the blade height in the vicinity of the propeller disc was also observed. Author

A89-23183*# Sterling Federal Systems, Inc., Palo Alto, CA.
UNSTEADY TRANSONIC FLOW SIMULATION ON A FULL-SPAN-WING-BODY CONFIGURATION

GURU P. GURUSWAMY (Sterling Federal Systems, Inc., Palo Alto, CA) and PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1450-1456. Research supported by USAF. Previously cited in issue 18, p. 2804, Accession no. A87-42337. refs

A89-23184*# Flow Research, Inc., Kent, WA.
EULER PROCEDURE FOR CORRECTING TWO-DIMENSIONAL TRANSONIC WIND-TUNNEL WALL INTERFERENCE

MAGDI H. RIZK, DONALD R. LOVELL (Flow Research Co., Kent, WA), and TIMOTHY J. BAKER (Princeton University, NJ) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1457-1466. Previously cited in issue 07, p. 928, Accession no. A88-22102. refs
(Contract NAS2-12157)

A89-23185#
HOLOGRAPHIC MEASUREMENTS OF TRANSITION AND TURBULENT BURSTING IN SUPERSONIC AXISYMMETRIC BOUNDARY LAYERS

A. GEORGE HAVENER (Dayton, University, OH) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1467-1476. Research supported by USAF. refs

Holographic interferometric density and velocity data of laminar and turbulent boundary layers, plus boundary-layer transition and turbulent bursting on sharp-tip cones in supersonic high Reynolds number airflows, are presented. Development of an improved numerical data-reduction process that minimizes the adverse effects of anomalies in interferometric measurements is also presented. From dual-plate holography, a special form of phase-shift interferometry is used to measure the fringe shifts, and by using a microcomparator to view the object waves directly as they are reconstructed from the holograms, a practical measuring resolution of 15 micrometers is obtained. This resolution is demonstrated by measuring eight fringe shifts for an 0.11 mm thick laminar boundary layer and again by measuring 66 fringe shifts for a turbulent boundary layer that is approximately 1.0 mm thick. These data are reduced to density and velocity distributions that are compared to theory to assess the relative error in the optical measurements. Author

A89-23186#
COMPUTATION OF THREE-DIMENSIONAL VISCOUS LINEAR CASCADE FLOWS

DOCHUL CHOI and CHARLES J. KNIGHT (Avco Research Laboratory, Inc., Everett, MA) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1477-1482. Research sponsored by Textron Lycoming's Research and Development Program. Previously cited in issue 07, p. 933, Accession no. A88-22265. refs

A89-23307*#
A NEW METHOD FOR THE AERODYNAMIC ANALYSIS OF LIFTING SURFACES

MAURICIO PAZINI BRANDAO AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs .
(Contract NGL-05-020-243)

The use of the original Ffowcs Williams and Hawkings equation to improve the solution to simple problems of two-dimensional and incompressible flow is studied. It is shown that a linear formulation, with the quadrupole term neglected, leads to better correlation with the results of potential theory. A solution to steady and two-dimensional problems is developed and applied to families of elliptic cylinders and symmetric airfoils. K.K.

A89-23309*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF NON-LINEAR ACOUSTICS IN TWO-DIMENSIONAL BLADE-VORTEX INTERACTIONS
J. D. BAEDER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 17 p. refs

The propagation characteristics of the interaction between a vortex and a helicopter airfoil are investigated by a variety of methods, and a comparison is made between solutions to the linearized transonic small disturbance equation, transonic small disturbance equation, Euler equations, and Navier-Stokes equations. Although the first two methods are able to accurately predict the propagation of acoustic waves, they are unable to accurately describe the initial formation of acoustic waves. The Euler and Navier-Stokes equations are shown to be well suited to the investigation of acoustic waves and give approximately the same results. V.L.

A89-23321#
A VORTEX EMBEDDING METHOD FOR FREE WAKE ANALYSIS OF HELICOPTER ROTOR BLADES IN HOVER
JOHN STEINHOFF and K. RAMACHANDRAN (Tennessee, University, Tullahoma) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 19 p. refs

A method for computing flow over helicopter rotor blades is presented which uses a compressible potential flow field with embedded vortex sheets. The wake is treated as a continuous sheet, in a unified manner, with no assumptions made as to how close it approaches other blades and without breaking the computational region into separate subgrids near the blades. The method has been implemented in a computer code, HELIX 1, and tested by computing a number of hover cases. Good agreement with experimental data is obtained in surface pressures and wake geometry for both subsonic and transonic cases, and for both two- and four-blade rotors. V.L.

A89-23338#
TOWARD A UNIFIED REPRESENTATION OF ROTOR BLADE AIRLOADS WITH EMPHASIS ON UNSTEADY AND VISCOUS EFFECTS
U. LEISS and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 17 p. Research supported by BMFT. refs

A model developed to unify the representation of rotor blade airloads which has no limitations in Mach number and angle of attack is presented. The superposition of different flow types gives a systematic structure of the steady flow in the attached and separated flow regime. This new approach is valid for all aerodynamic coefficients in a generalized way. K.K.

A89-23343#
ASPECTS OF WIND TUNNEL INTERFERENCE EFFECTS ON ROTOR MODEL LOADINGS
HANS-JUERGEN LANGER (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 19 p. refs

Procedures are presented for correcting wind tunnel measurements in order to compare them with full-scale rotor measurements. The procedures include applying full-scale control angles to the rotor model, adjusting scale hub loads from flight tests and calculations to the rotor model, and using wind tunnel derivative measurements. It is found that correction factors generally decrease with increasing wind tunnel velocity. An example using the methods is presented, showing the effect of a movable rig on rotor hub loads. R.B.

A89-23344#
MODEL ROTOR WAKE MEASUREMENTS IN A WIND TUNNEL
B. JUNKER (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany), W. GRADL, and V. MIKULLA (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 24 p. refs

The induced velocity field in the rotor wake of a 4 m diameter model rotor mounted in the DNW-wind tunnel was measured. The measurements consisted of triple hot wire sensor data of the steady and unsteady components of the induced velocity in five different parallel planes below the rotor disk. The best agreement between calculations and direct measurements was obtained in a plane 10 cm below the rotor and particularly in the transition flight case. K.K.

A89-23362#
RESULTS FROM THE GLASGOW UNIVERSITY BLADE/VORTEX INTERACTION (B.V.I.) FACILITY
A. KOKKALIS and R. A. MCD. GALBRAITH (Glasgow, University, Scotland) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 27 p. Sponsorship: Ministry of Defence. refs
(Contract MOD-2048/30)

A wind tunnel test program using an instrumented model rotor blade has been conducted to determine both representative and critical blade/vortex interaction (BVI) airloads. In particular, the parallel BVI case was investigated in detail; instantaneous blade airloads were measured for a variety of vortex strengths and blade/vortex separation distances at two spanwise locations. The data revealed that the basic effect of the vortex interactions was a rapid continuous pressure pulse, predominately manifesting itself over the forward 25 percent of the airfoil. Comparisons of the measured normal force coefficient history with that predicted by the method of Beddoes (1987) show good agreement, both in magnitude and shape. Author

A89-23368#
EFFECTS OF AXIAL FORCE ON THE FLUTTER OF HIGH ASPECT RATIO AEROFOIL BLADES
J. R. BANERJEE (City University, London, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 11 p. refs

The effect of axial force on the flutter characteristics of high aspect ratio airfoil blades is investigated by the finite element method and two-dimensional unsteady aerodynamics. Within the range of practical interest (where the torsional frequency is much higher than the bending frequency) the axial force is found to have no significant effect on the classical bending-torsion flutter of high aspect ratio blades. Although the flutter speed is virtually unchanged, the axial force has a marginal effect on flutter frequency, with a compressive load reducing the flutter frequency and a tensile load increasing it. V.L.

A89-23688
A SEMIEMPIRICAL METHOD FOR CALCULATING SEPARATED TURBULENT FLOW IN A CONICAL LAVAL NOZZLE IN THE REEXPANSION MODE [POLUEMPIRICHESKII METOD RASCHETA TURBULENTNOGO OTRYVNOGO TECHENIIA V KONICHESKOM SOPLE LAVALIA NA REZHIME PERERASSHIRENIIA]
T. I. MALIK and R. K. TAGIROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1988, p. 60-66. In Russian. refs

A mathematical model describing separated flow in a nozzle is developed with allowance for the effect of the wall boundary layer and pressure variation along the separation zone inside the nozzle. The effect of geometrical and gasdynamic parameters on the separated flow pattern is investigated numerically. The results obtained are presented in graphic form. V.L.

A89-23690
ASYMPTOTIC STRUCTURE OF NONVISCOUS PERTURBATIONS IN A THIN SHOCK LAYER [ASIMPTOTICHESKAIA STRUKTURA NEVIAZKIKH VOZMUSHCHENII V TONKOM UDARNOM SLOE]

V. R. GUSHCHIN and A. V. FEDOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1988, p. 72-79. In Russian. refs

Different kinds of nonviscous three-dimensional short-wave perturbations in a thin shock layer of an ideal gas with arbitrary transverse velocity and temperature distributions are investigated by the WKB method. Simple analytical expression of dispersion relations are obtained for neutral perturbations. The results of an asymptotic analysis are compared with direct numerical calculations for a simple shock layer model. V.L.

A89-23692
ONE-DIMENSIONAL TRANSONIC GAS FLOW IN A POROUS-WALL WIND TUNNEL [ODNOMERNOE OKOLOZVUKOVOE TECHENIE GAZA V AERODINAMICHESKOI TRUBE S PERFORIROVANNYMI STENKAMI]
V. M. NEILAND Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1988, p. 143-148. In Russian. refs

Flow of a nonviscous gas in the test section of a porous-wall wind tunnel in the transonic region is investigated in the context of one-dimensional theory with Darcy's boundary condition. Calculations are carried out for a wind tunnel with a slope of 0.05 deg and 4-percent porosity. The results are found to be in good agreement with experimental data. V.L.

A89-23693
EFFECT OF VISCOSITY ON THE AERODYNAMIC EFFICIENCY OF A THIN BLUNT WING AT HYPERSONIC FLOW VELOCITIES [VLIIANIE VIAZKOSTI NA AERODINAMICHESKOE KACHESTVO TONKOGO ZATUPLENNOGO KRYLA PRI GIPERZVUKOVYKH SKOROSTIAKH OBTEKANIIA]
P. I. GORENBUKH and V. S. NIKOLAEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1988, p. 149-152. In Russian.

The effect of viscosity on the lift properties of a hypersonic wing is calculated approximately by the band method for the case of weak viscous interaction. Local friction coefficients and boundary layer induced additional pressure are determined from data for an infinite-span plate. Simple relations are obtained which make it possible to estimate the effect of viscosity on maximum aerodynamic efficiency and the corresponding angle of attack. These relations are supported by results of an experimental study of hypersonic flow past a delta wing over a wide range of Reynolds numbers. V.L.

A89-23723
A NUMERICAL SCHEME FOR MODELING SUBSONIC FLOWS OF A VISCOUS COMPRESSIBLE GAS [CHISLENNAIA SKHEMA MODELIROVANIIA DOZVUKOVYKH TECHENII VIAZKOGO SZHIMAEMOGO GAZA]
V. A. GONCHAROV, V. M. KRIVTSOV, and A. A. CHARAKHCH'IAN Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 28, Dec. 1988, p. 1858-1866. In Russian. refs

A difference scheme for two-dimensional flows of a compressible gas is proposed whose efficiency is comparable with that of schemes for incompressible fluid equations. The efficiency of the scheme depends on an original iteration process employing a pressure exclusion procedure characteristic of equations for an incompressible fluid. A comparison with other schemes is made by considering a model convection problem as an example. V.L.

A89-23811
STABILITY OF THREE-DIMENSIONAL BOUNDARY LAYERS AND LAMINAR WINGS [STABILITAET DREIDIMENSIONALER GRENZSCHICHTEN UND LAMINARFLUEGEL]
HANS BIPPES, BERNHARD MUELLER, HANS-PETER KREPLIN, and GEBHARD HOEHLER (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 17-21. In German. refs

Research programs on three-dimensional boundary layers conducted in order to develop fuel-saving laminar wings for aircraft are discussed. Experimental studies of flow instabilities in three-dimensional boundary layers and in three-dimensional ram flows are addressed. The application of the e(n) criterion in the three-dimensional boundary layer is discussed, and hot-film measurements made on the ATTAS 'laminar glove' are examined. C.D.

A89-23812
NUMERICAL METHODS AND HIGH-PERFORMANCE COMPUTERS - NEW DEVELOPMENT TOOLS IN AERODYNAMICS [NUMERISCHE VERFAHREN UND HOECHSTLEISTUNGSRECHNER - NEUE ENTWICKLUNGSWERKZEUGE IN DER AERODYNAMIK]
HERBERT OERTEL and WILHELM KORDULLA (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 22-27. In German.

The development of new technologies in air and space transport requires the use of numerical methods for vectorial computers. The types of methods applied in the various types of vectorial computers are described, and present applications to air flight aerodynamics and space flight thermodynamics are examined. Future applications are briefly considered. C.D.

A89-23818
VORTEX STREETS AND THEIR EFFECTS ON AIR TRAFFIC [WIRBELSCHLEPPEN UND IHRE AUSWIRKUNGEN AUF DEN LUFTVERKEHR]
ROLF ULKEN (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 52-55. In German.

The characteristics and behavior of vortex streets caused by aircraft are reviewed, and the hazards they pose for air traffic are considered. The degree of danger involved in single landing strips, double landing strips, and takeoff and landing strips that cross is examined. Recommendations for minimizing the hazards are made. C.D.

A89-23873
DESIGN FEATURES WHICH INFLUENCE FLOW SEPARATIONS ON AIRCRAFT
D. G. MABEY (Royal Aerospace Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, Dec. 1988, p. 409-415. refs

Features of aircraft which influence flow separations, and hence the onset of buffeting, should be always of interest to an aerodynamicist. The present compilation of such features is based on notes made during a visit to the USAF Aircraft Museum in Dayton, Ohio. Although two low-speed aircraft with high aspect ratio wings are considered, the emphasis is primarily on transonic and supersonic military aircraft, with wings of lower aspect ratio. Some recommendations are made to stimulate research into improved methods to control flow separation, particularly for future transonic and supersonic aircraft. Author

A89-23978#
A NEW NUMERICAL METHOD FOR SUBSONIC LIFTING SURFACES - BIS (SOME ADDITIONAL COMPUTATIONAL RESULTS)
MASAMI ICHIKAWA (Nagoya, Government Industrial Research Institute, Japan) and SHIGENORI ANDO (Nagoya University, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, Nov. 1988, p. 146-156. refs

Results are presented from a previous study concerning the Box-In-Strip (BIS) computational method for unsteady subsonic lifting surfaces (Ando and Ichikawa, 1986). The BIS method is compared with the Piecewise Continuous Kernel-Function Method (PCKFM). For the case of a rectangular wind with an aspect ration

of 10, the BIS and PCKFM methods provide similar results. The BIS results are also compared with analytical solutions for circular and/or elliptical wing planforms in steady incompressible flow. It is shown that the correlation between BIS and the analytical solutions is better than that between the vortex lattice method and the solutions. R.B.

A89-24242#
TRANSONIC EULER SOLUTIONS ON A BLUNT, BODY-WING-CANARD CONFIGURATION
LAWRENCE E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Nov.-Dec. 1988, p. 393-399. Previously cited in issue 21, p. 3336, Accession no. A87-49055. refs

A89-24301#
APPLICATION OF A FULL POTENTIAL METHOD TO SUPERSONIC AIRCRAFT DESIGN AND ANALYSIS
KENNETH B. WALKLEY and GREGORY E. SMITH (Dynamic Engineering, Inc., Newport News, VA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 491-501) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 6-12. Previously cited in issue 24, p. 3531, Accession no. A86-49030. refs
(Contract AF TASK 0130-26)

A89-24302#
IMPROVEMENTS TO AN EULER AERODYNAMIC METHOD FOR TRANSONIC FLOW ANALYSIS
PRADEEP RAJ and JAMES E. BRENNAN (Lockheed Aeronautical Systems Co., Burbank, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 13-20. Previously cited in issue 08, p. 1032, Accession no. A87-22373. refs
(Contract F33615-84-C-3005)

A89-24303*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR REALISTIC AIRCRAFT CONFIGURATIONS
JOHN T. BATINA, DAVID A. SEIDEL, SAMUEL R. BLAND, and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 344-362) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 21-28. Previously cited in issue 14, p. 2102, Accession no. A87-33690. refs

A89-24304#
NUMERICAL STUDY OF A RESEARCH CIRCULATION CONTROL AIRFOIL USING NAVIER-STOKES METHODS
GEORGE D. SHREWSBURY (Lockheed Aeronautical Systems Co., Marietta, GA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 29-34. Previously cited in issue 08, p. 1044, Accession no. A87-22754. refs

A89-24305#
ANALYTIC PREDICTION OF THE MAXIMUM AMPLITUDE OF SLENDER WING ROCK
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 35-39. Previously cited in issue 22, p. 3530, Accession no. A87-49605. refs

A89-24307*# Flow Research, Inc., Kent, WA.
EULER PROCEDURE FOR THREE-DIMENSIONAL TRANSONIC WALL INTERFERENCE
MAGDI H. RIZK, DONALD R. LOVELL (Flow Research, Inc., Kent, WA), and TIMOTHY J. BAKER (Princeton University, NJ) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 48-55. refs
(Contract NAS2-12157)

Based on an optimization formulation, a procedure has been developed to evaluate Mach number and angle-of-attack corrections. The Euler equations are assumed to be the flow governing equations. To obtain efficient solutions for the optimization problem, the iterative solutions for the flow variables and the design parameters are simultaneously updated. In addition to the model lift and geometry, the procedure requires pressure measurements near the tunnel walls. The tunnel boundary conditions are based on the introduction of Reimann invariants for a one-dimensional flow normal to the boundary. Computations are performed to verify that the errors introduced by this approximate boundary-condition formulation are acceptably small. The correction scheme is applied to an aircraft configuration in an open jet. The results indicate that the optimization scheme is highly efficient with the rate of convergence of the flow solution nearly equal to the corresponding rate of a regular analysis problem. Author

A89-24308*# PRC Kentron, Inc., Hampton, VA.
SIMILARITY FOR HIGH-ANGLE-OF-ATTACK SUBSONIC/TRANSONIC SLENDER-BODY AERODYNAMICS
M. J. HEMSCH (PRC Kentron, Inc., Aerospace Technologies Div., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 56-66. Previously cited in issue 07, p. 929, Accession no. A88-22158. refs
(Contract NAS1-18000)

A89-24312*# General Electric Co., Evendale, OH.
SEPARATED FLOWS DEVELOPING UNDER INCREASINGLY ADVERSE PRESSURE GRADIENTS
JAYESH M. MEHTA (General Electric Co., Aircraft Engine Business Group, Evendale, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 91-93. refs
(Contract NAS1-13985)

Experimental results are presented for separating flows over a NASA GA(W)-1 airfoil with 2-percent trailing-edge thickness, with emphasis on the mean velocity data that demonstrate flowfield similarity downstream of separation. The length scale presently employed was selected because it furnishes the requisite matching point between the outer, mixing region flow and the back-flow. O.C.

A89-24313*# General Electric Co., Evendale, OH.
SELF-PRESERVATION OF TURBULENT WAKES
JAYESH M. MEHTA (General Electric Co., Aircraft Engine Business Group, Evendale, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 93-96. refs
(Contract NAS1-13985)

The present experiment has ascertained the development of the wake flow behind NASA GA(W)-1 airfoils, showing that, in the far wake, the mean velocity profiles exhibit self-similar behavior irrespective of the upstream boundary layer's character. It is noted, however, that the processes by means of which different wakes reach the asymptotic stage can be very different for different types of wake generators. O.C.

A89-24319#
MEASUREMENTS OF WALL PRESSURE AND HEAT TRANSFER RATE IN THE INTERACTION REGIONS OF SHOCK WAVES AND TURBULENT BOUNDARY LAYERS INDUCED BY BLUNT FINS
SHIGERU ASO, MASANORI HAYASHI, ANZHONG TAN, and SEISHI KURANAGA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Oct. 1988, p. 705-710. In Japanese, with abstract in English. refs

The wall pressure and heat transfer rate are measured in the interaction regions of shock waves and turbulent boundary layers induced by blunt fins with hemicylindrical leading edges at Mach number 4, Reynolds number 1.26 x 10 to the 7th, and angle of attack of zero degree. Fins with leading edge diameters of 6 and 10 mm are used to examine the influence of leading edge diameter on the wall pressure and heat transfer distributions. Detailed streamwise distributions of both the wall pressure and heat transfer rate are measured for a wide range of the interaction regions. The results show that the streamwise pressure and heat transfer distribution have two significant peaks near the fins, while an

additional peak appears in the streamwise heat transfer distribution in the outboard regions. Pressure and heat transfer distributions whose streamwise distances are scaled by the leading edge diameters of the fins are compared. The results show that the flow fields have similar structures. C.D.

A89-24657
SMALL SPACING ASYMPTOTICS FOR SUBSONIC NONSTATIONARY FLOW AROUND A THIN PROFILE NEAR A SOLID BOUNDARY [ASIMPTOTIKA MALYKH OTSTOIANII DLIA DOZVUKOVOGO NESTATSIONARNOGO OBTEKANIIA TONKOGO PROFILIA VBLIZI TVERDOI GRANITSY]
I. I. EFREMOV (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR) Dinamicheskie Sistemy (ISSN 0203-3755), no. 7, 1988, p. 48-53. In Russian.

The problem of the harmonic vibrations of a thin profile moving at a subsonic velocity near a plane solid boundary is solved analytically using the asymptotic approximation of small spacings. Results of lift force calculations are presented. It is noted that the lift force depends nonmonotonically on the Strouhal number. V.L.

A89-24823* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION OF TRANSONIC VISCOUS WING AND WING-FUSELAGE FLOWS USING ZONAL METHODS
JOLEN FLORES (NASA, Ames Research Center, Moffett Field, CA) IN: International Symposium on Domain Decomposition Methods for Partial Differential Equations, 1st, Paris, France, Jan. 7-9, 1987, Proceedings. Philadelphia, PA, SIAM, 1988, p. 381-416. refs

The thin-layer Navier-Stokes equations are coupled with a zonal scheme (or domain-decomposition method) to develop the Transonic Navier-Stokes (TNS) wing-alone code. TNS has a total of four zones and is extended to a total of 16 zones for the wing-fuselage version of the code. Results are computed on the Cray X-MP-48 and compared with experimental data. Author

A89-24824
BLOCK-STRUCTURED SOLUTION OF TRANSONIC FLOWS
A. ECER (Purdue University, Indianapolis, IN) IN: International Symposium on Domain Decomposition Methods for Partial Differential Equations, 1st, Paris, France, Jan. 7-9, 1987, Proceedings. Philadelphia, PA, SIAM, 1988, p. 417-425. refs

A computational scheme for the block-structured solution of transonic flows is developed. A complex three-dimensional flow problem is divided into a number of smaller subregions (blocks). The computational grid is generated for each of the blocks and assembled into a single grid. The flow equations are again solved individually for each block and iteratively combined to provide a global solution. Potential, Euler, and Navier-Stokes equations can be solved for each of the blocks. The paper summarizes the procedure and discusses its applications on different computers. Author

N89-15074*# San Jose State Univ., CA. Dept. of Mechanical Engineering.
AERODYNAMIC MANEUVERING HYPERSONIC FLIGHT MECHANICS Final Report, 1 Jun. 1987 - 30 Sep. 1988
DICK DESAUTEL 4 Nov. 1988 18 p
(Contract NAG2-457)
(NASA-CR-183007; NAS 1.26:183007) Avail: NTIS HC A03/MF A01 CSCL 01A

The emergence of current high-interest mission involving aeromaneuvering hypersonic flight has given rise to the corresponding need for preliminary design and performance analyses of such vehicles. This need in turn has motivated efforts to develop simplified analytical and computational methods for parametric analysis of maneuvering hypersonic flight under conditions appropriate to the mission involved. The effort included a review of different formulations of the general equations of motion, their associated coordinate frames, various simplifications of the equations, and previously achieved analytical solutions. This study sought to both extend previous solution methods and to develop new ones. In addition, evaluation of the literature and developing a systematic perspective on the knowledge it represents proved to be a major portion of the effort. Author

N89-15075 Leicester Univ. (England).
AERODYNAMIC DRAG OF RIDGE ARRAYS IN ADVERSE PRESSURE GRADIENTS Ph.D. Thesis
M. F. ABD RABBO 1976 234 p
Avail: Univ. Microfilms Order No. BRD-82088

Drag measurements for excrescence arrays of square section mounted on a smooth wall and subject to two adverse pressure gradients in equilibrium are obtained. Differences in drag which arise when the excrescence are uniformly distributed and when tending to isolation are shown. Flow visualization photographs using the surface oil flow technique are presented to illustrate different flow patterns around arrays of varying spacing. A prediction model for the drag of excrescence arrays based on the results obtained was devised. Its range of appiication could be extended to excrescences of varying shape providing they are sufficiently small to be immersed in the logarithmic part of the boundary layer. Drag results are determined by both a momentum defect and a pressure distribution technique. These results are compared and the difference between them is partially attributed to the change in the surface friction between the excrescence and partially to some lack of two-dimensionality in the test procedures. Corrections for the latter effect are made to the data obtained. Dissert. Abstr.

N89-15076# Naval Underwater Systems Center, New London, CT. Launcher and Missile Systems Dept.
AERODYNAMIC DRAG OF CYLINDRICAL VEHICLES MOVING CONCENTRICALLY WITHIN LONG TUBES
D. A. KOTLOW 9 Mar. 1988 128 p
(AD-A197947; NUSC-TR-6638) Avail: NTIS HC A07/MF A01 CSCL 20D

A numerical analysis is made of developing and developed turbulent flow in the annular region between a cylinder moving at constant velocity within a fixed concentric tube. Turbulent shear is modeled by eddy viscosity, and a uniform velocity is assumed at the entrance to the annular region. The computations extend and modify the method of Sud and Chaddock (1981) to arbitrary Reynolds numbers and radius ratios. While this report is based on the author's masters thesis, the fully developed flow results are more complete, and those for developing flow are more accurate. Better accuracy was achieved by implementing double precision, which enabled the computations to be performed further into the developing region. GRA

N89-15077*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF A LOWER-UPPER IMPLICIT SCHEME AND AN INTERACTIVE GRID GENERATION FOR TURBOMACHINERY FLOW FIELD SIMULATIONS
YUNG K. CHOO, WOO-YUNG SOH, and SEOKKWAN YOON (MCAT Inst., Moffett Field, CA.) 1989 17 p Proposed for presentation at the 34th International Gas Turbine and Aeroengine Congress and Exposition, Toronto, Ontario, 4-8 Jun. 1989; sponsored by the American Society of Mechanical Engineers
(NASA-TM-101412; E-4374; NAS 1.15:101412) Avail: NTIS HC A03/MF A01 CSCL 01A

A finite-volume lower-upper (LU) implicit scheme is used to simulate an inviscid flow in a tubine cascade. This approximate factorization scheme requires only the inversion of sparse lower and upper triangular matrices, which can be done efficiently without extensive storage. As an implicit scheme it allows a large time step to reach the steady state. An interactive grid generation program (TURBO), which is being developed, is used to generate grids. This program uses the control point form of algebraic grid generation which uses a sparse collection of control points from which the shape and position of coordinate curves can be adjusted. A distinct advantage of TURBO compared with other grid generation programs is that it allows the easy change of local mesh structure

without affecting the grid outside the domain of independence. Sample grids are generated by TURBO for a compressor rotor blade and a turbine cascade. The turbine cascade flow is simulated by using the LU implicit scheme on the grid generated by TURBO. Author

N89-15078*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOT GAS INGESTION TESTING OF AN ADVANCED STOVL CONCEPT IN THE NASA LEWIS 9- BY 15-FOOT LOW SPEED WIND TUNNEL WITH FLOW VISUALIZATION
ALBERT L. JOHNS, JOSEPH D. FLOOD, THOMAS W. STROCK, and KURT C. AMUEDO (McDonnell-Douglas Corp., St. Louis, MO.) 1988 27 p Presented at the 24th Joint Propulsion Conference, Boston, MA, 11-13 Jul. 1988; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-100952; E-4250; NAS 1.15:100952; AIAA-88-3025) Avail: NTIS HC A03/MF A01 CSCL 01A

Advanced Short Takeoff/Vertical Landing (STOVL) aircraft capable of operating from remote sites, damaged runways, and small air capable ships are being pursued for deployment around the turn of the century. To achieve this goal, it is important that the technologies critical to this unique class of aircraft be developed. Recognizing this need, NASA Lewis Research Center, McDonnell Douglas Aircraft, and DARPA defined a cooperative program for testing in the NASA Lewis 9- by 15-Foot Low Speed Wind Tunnel (LSWT) to establish a database for hot gas ingestion, one of the technologies critical to STOVL. Results from a test program are presented along with a discussion of the facility modifications allowing this type of testing at model scale. These modifications to the tunnel include a novel ground plane, an elaborate model support which included 4 degrees of freedom, heated high pressure air for nozzle flow, a suction system exhaust for inlet flow, and tunnel sidewall modifications. Several flow visualization techniques were employed including water mist in the nozzle flows and tufts on the ground plane. Headwind (free-stream) velocity was varied from 8 to 23 knots. Author

N89-15079# Tennessee Univ. Space Inst., Tullahoma. Gasdynamics Div.
INVESTIGATION OF PHENOMENA OF DISCRETE WINGTIP JETS Final Technical Report, May 1986 - Aug. 1988
J. M. WU, A. D. VAKILI, Z. SHI, and J. D. MO Aug. 1988 60 p
(Contract AF-AFOSR-0155-86; AF PROJ. 2307)
(AD-A199962; UTSI-88-06; AFOSR-88-0937TR) Avail: NTIS HC A04/MF A01 CSCL 20D

Detail flow phenomena of discrete wingtip jets blowing from a rectangular wing with squared edges and round tips are investigated in the water-and wind-tunnel experiments. Phenomena on a single asymmetric jet blowing from a flat-plate in crossflow were incorporated into the present wingtip jet study. The local flow field perturbation introduced by the tip jet blowing closely resembles that of the asymmetric jet from the flat-plate. The wingtip jet has influenced the global surface pressure distribution over the wing and improved the lift loading. A simple mathematical model is developed for practical calculation of wing loading. GRA

N89-15080# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
HEAT TRANSFER RATES ON AN ANALYTIC FOREBODY IN THE AFWAL (AIR FORCE WRIGHT AERONAUTICAL LABORATORIES) MACH 3 HIGH REYNOLDS NUMBER WIND TUNNEL. COMPARISON OF TEST RESULTS WITH PREDICTIONS FROM STAPAT (A SPECIFIC THERMAL ANALYZER PROGRAM FOR AIRCRAFT TRANSPARENCIES) Final Report, Oct. 1984 - Sep. 1986
CHARLES A. BABISH, III and JAMES R. HAYES 22 Apr. 1988 112 p
(AD-A199523; AFWAL-TR-87-3091) Avail: NTIS HC A06/MF A01 CSCL 01A

This report describes a wind tunnel test program and the STAPAT computer program which were used to study heat transfer rates on an analytic forebody at Mach 3.0. STAPAT, a Specific Thermal Analyzer Program for Aircraft Transparencies, defines aerodynamic heating environments over windshields and canopies of high speed aircraft. STAPAT predictions were compared with measurements on an analytic forebody whose shape is representative of the forward fuselage of an aircraft. The measurements on an analytic forebody whose shape is representative of the forward fuselage of an aircraft. The Reynolds numbers and supersonic speeds in a cold flow wind tunnel. This technique incorporated a means for raising the temperature of the outer surface of the analytic forebody above the recovery temperature of the tunnel which was operated at stagnation temperatures near atmospheric. Heat transfer rates were significantly influenced by tunnel stagnation temperatures. gage surface temperatures and water temperatures. Use of a nondimensional heat transfer coefficient, the Stanton number, effectively eliminated heat transfer rate dependency upon these temperatures and therefore was shown to be the best way to evaluate heat transfer rates over the analytic forebody. The magnitudes of the measured heat transfer rates, their distribution over the analytic forebody and their good agreement with STAPAT calculations. GRA

N89-15082*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
SHOCK TUBE INVESTIGATION OF DYNAMIC RESPONSE OF PRESSURE TRANSDUCERS FOR VALIDATION OF ROTOR PERFORMANCE MEASUREMENTS
DANIEL BERSHADER Dec. 1988 31 p
(Contract NCC2-549)
(NASA-CR-182673; NAS 1.26:182673; SU-AERO-48-88) Avail: NTIS HC A03/MF A01 CSCL 01A

For some time now, NASA has had a program under way to aid in the validation of rotor performance and acoustics codes associated with the UH-60 rotary-wing aircraft; and to correlate results of such studies with those obtained from investigations of other selected aircraft rotor performance. A central feature of these studies concerns the dynamic measurement of surface pressure at various locations up to frequencies of 25 KHz. For this purpose, fast-response gauges of the Kulite type are employed. The latter need to be buried in the rotor; they record surface pressures which are transmitted by a pipette connected to the gauge. The other end of the pipette is cut flush with the surface. In certain locations, the pipette configuration includes a rather sharp right-angle bend. The natural question has arisen in this connection: In what way are the pipettes modifying the signals received at the rotor surface and subsequently transmitted to the sensitive Kulite transducer element. The basic details and results of the program performed and recently completed in the High Pressure Shock Tube Laboratory of the Department of Aeronautics and Astronautics at Stanford University are given. Author

N89-15083# European Space Agency, Paris (France).
EXPERIMENTAL INVESTIGATION OF PROPAGATION OF SHOCKWAVE INDUCED DISTURBANCES IN TRANSONIC AIRFOILS
DIETER BASLER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) Sep. 1988 139 p Transl. into ENGLISH of Experimentelle Untersuchung der Ausbreitung Stossinduzierter Stoerungen an Transsonischen Profilen (Goettingen, Fed. Republic of Germany, DFVLR) Jul. 1987 128 p Original language document was announced as N88-16666
(ESA-TT-1097; DFVLR-FB-87-28; ETN-89-93634) Avail: NTIS HC A07/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 38 Deutsche marks

The mechanism of buffeting was investigated in a wind tunnel on a transonic airfoil. A holographic high speed real time interferometer was developed to observe and analyze the entire flow field surrounding the airfoil. The information from interferograms was compared with results from hot film and pressure measurements. The results show that the shock oscillation can be described by an interaction of the shock with the boundary

layer and the flow conditions at the trailing edge of the airfoil. The observed buffet frequencies are higher for an initially laminar boundary layer than for a turbulent boundary layer. Buffet frequency decreases with increasing Reynolds number in the case of a turbulent boundary layer. ESA

N89-15084*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EXPERIMENTAL INVESTIGATION OF MULTI-ELEMENT AIRFOIL ICE ACCRETION AND RESULTING PERFORMANCE DEGRADATION
MARK G. POTAPCZUK and BRIAN M. BERKOWITZ (Sverdrup Technology, Inc., Cleveland, OH.) 1989 40 p Presented at the 27th Aerospace Sciences Meeting, Reno, NV, 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-101441; E-4546; NAS 1.15:101441; AIAA-89-0752)
Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation of the ice accretion pattern and performance characteristics of a multi-element airfoil was undertaken in the NASA Lewis 6- by 9-Foot Icing Research Tunnel. Several configurations of main airfoil, slat, and flaps were employed to examine the effects of ice accretion and provide further experimental information for code validation purposes. The test matrix consisted of glaze, rime, and mixed icing conditions. Airflow and icing cloud conditions were set to correspond to those typical of the operating environment anticipated tor a commercial transport vehicle. Results obtained included ice profile tracings, photographs of the ice accretions, and force balance measurements obtained both during the accretion process and in a post-accretion evaluation over a range of angles of attack. The tracings and photographs indicated significant accretions on the slat leading edge, in gaps between slat or flaps and the main wing, on the flap leading-edge surfaces, and on flap lower surfaces. Force measurments indicate the possibility of severe performance degradation, especially near C sub Lmax, for both light and heavy ice accretion and performance analysis codes presently in use. The LEWICE code was used to evaluate the ice accretion shape developed during one of the rime ice tests. The actual ice shape was then evaluated, using a Navier-Stokes code, for changes in performance characteristics. These predicted results were compared to the measured results and indicate very good agreement. Author

N89-15086*# Washington Univ., Seattle. Dept. of Aeronautics and Astronautics.
AERODYNAMICS OF VORTEX GENERATORS Final Report, Jan. 1984 - Dec. 1987
ROBERT E. BREIDENTHAL, JR. and DAVID A. RUSSELL 1988 7 p
(Contract NAG2-283)
(NASA-CR-182511; NAS 1.26:182511) Avail: NTIS HC A02/MF A01 CSCL 01A

An experimental and theoretical study was undertaken of the separation delay and dramatic boundary-layer thinning that can occur in vortex-generator installations. Wind tunnel measurements of the dynamic-pressure profile downstream of a vortex generator were found to compare under certain conditions with that downstream of a suction slit, while water-tunnel visualization studies of vortex-generator height and geometry suggested optimum configurations, and only a minor effect of base porosity. A series of progressively more complex inviscid flow models was developed to be applied to a 3-D integral boundary-layer code. This code predicted layer thinning downstream of the suction site of the vortex models, and other observed features. Thin-layer Navier-Stokes equations are now being used with the ultimate goal of clarifying the physical processes involved in vortex generator performance and developing calculational procedures capable of predicting it. Author

N89-15087*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLUTTER ANALYSIS OF HIGHLY SWEPT DELTA WINGS BY CONVENTIONAL METHODS
M. D. GIBBONS, D. L. SOISTMANN (PRC Systems Services Co., Hampton, VA.), and R. M. BENNETT Nov. 1988 20 p
(NASA-TM-101530; NAS 1.15:101530) Avail: NTIS HC A03/MF A01 CSCL 01A

The flutter boundaries of six thin highly-swept delta-platform wings have been calculated. Comparisons are made between experimental data and results using several aerodynamic methods. The aerodynamic methods used include a subsonic and supersonic kernel function, second order piston theory, and a transonic small disturbance code. The dynamic equations of motion are solved using analytically calculated mode shapes and frequencies. Author

N89-15088*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATION EFFECTS OF PYLON GEOMETRY ON A HIGH-WING TRANSPORT AIRPLANE
JOHN R. CARLSON and MILTON LAMB Washington, DC Feb. 1989 78 p
(NASA-TP-2877; L-16489; NAS 1.60:2877) Avail: NTIS HC A05/MF A01 CSCL 01A

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the installation effects of a series of pylons that had differing cross-sectional shapes on the pressure distributions and aerodynamic characteristics of a 1/24-scale high wing transport. The tests were conducted at Mach numbers at 0.70 and 0.80 at angles of attack from -3 degrees to 4 degrees with the pylons tested at various toe angles between 5 degrees inboard and 5 degrees outboard. Results of this study indicate that the installed drag was lowest for the pylons with a compression pylon type design which kept the flow under the wing in the pylon/wing junction comparable to the clean wing velocities. Author

N89-15889 Cranfield Inst. of Tech., Bedford (England).
TRAILING EDGE STRIPS TO REDUCE THE DRAG OF SLENDER WINGS Ph.D. Thesis
R. J. BRUCE 1988 223 p
Avail: Univ. Microfilms Order No. BRDX82024

A slender delta is the ideal layout for good supersonic performance but the intense vorticity in the wake creates very high drag during maneuvering and at low speeds. It should be possible to recover some of the rotational energy from the wakes by placing small fins in the strong sideways flows under the vortices so as to provide a thrust. A further development of this idea is to position long slender fins (or trailing edge strips) in the upwards flow around the vortices in the wake. They provide a lift and thrust over a wide CL range without harming the flow over the wing. This thesis traces the development of these strips in a series of low-speed wind tunnel tests. They were found to reduce the lift-dependent drag of a slender wing by 10 to 15 percent at moderate angles of attack without penalizing the performance at very high angles of attack or in the cruise. A few inherent stability problems have been identified but ways to minimize them are suggested. During the course of the study the near-wake flow of a slender delta wing has been extensively studied. No supersonic tests have been carried out but the strips can be stowed, if necessary, during supersonic flight. Dissert. Abstr.

N89-15890 Michigan Univ., Ann Arbor.
AN ANALYSIS OF THE TRANSONIC FLOW THROUGH A LIGHTLY LOADED COMPRESSOR ROTOR Ph.D. Thesis
HEMANT KAMATH 1988 130 p
Avail: Univ. Microfilms Order No. DA8812918

Three-dimensional transonic flow through a lightly loaded compressor rotor is analyzed using the method of matched asymptotic expansions. The velocity field as seen by a blade-fixed observer can be represented as a sum of an undisturbed relative velocity (which is a function of the local radius) and a perturbation which can be expressed in terms of a velocity potential to the order of approximation considered in the present analysis. Analytical solutions for the velocity components of a particular class of transonic flow are derived except for thin inner regions enclosing the leading and trailing edges of the blades where

numerical methods are employed to solve the simplified governing equations obtained from the asymptotoic analysis. Pressure coefficients and contours of constant Mach number are presented for the numerical examples considered in the analysis.
Dissert. Abstr.

N89-15891# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
AN ELLIPTIC GRID GENERATION METHOD FOR CROPPED DELTA WINGS Final Report, Mar. 1985 - Nov. 1986
JAMES R. SIRBAUGH Jul. 1988 56 p
(AD-A199462; AFWAL-TR-88-3050) Avail: NTIS HC A04/MF A01 CSCL 01A

The solution of the Euler equations for aircraft flow fields involves two major problems: grid generation and flow equation solution. A grid must be generated for each new configuration to be studied. The grid must accurately model the configuration surface geometry and provide sufficient grid resolution in the region around the configuration to capture the flow details. Grid generation methods should be tailored according to both the physics of the flow and the flow equation solution method. The primary flow characteristic of the delta wing is the leading edge separation that rolls up into a vortex. The vortex position, size and strength are dependent on many factors, one of which is the leading edge shape. The leading edge grid must be fine enough to permit the flow solver to capture the flow gradients contributing to leading edge separation in order to accurately predict vortex core position and strength. The Euler equation solver used in this work is FL057. While FL057 has previously been applied to delta wing configuration, the built-in grid generation in FL057 is inadequate for delta wings. A few aspects of FL057 should be kept in mind when considering a grid topology to be coupled to the Euler equation solver. A finite-volume and central-difference scheme is used. GRA

N89-15892 North Carolina State Univ., Raleigh.
AN INTERACTIVE THREE-DIMENSIONAL LAMINAR AND TURBULENT BOUNDARY-LAYER METHOD FOR COMPRESSIBLE FLOW OVER SWEPT WINGS Ph.D. Thesis
SHAWN HAROLD WOODSON 1988 112 p
Avail: Univ. Microfilms Order No. DA8815549

A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descritized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing-body inviscid code (FLO-30) and the inviscid interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from between 7 to 20 depending on the Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscid interaction method and with experimental values. Dissert. Abstr.

N89-15893*# Stanford Univ., CA. Joint Inst. for Aeronautics and Acoustics.
THEORETICAL STUDIES ON FLAPPED DELTA WINGS
S. OH, D. TAVELLA, and L. ROBERTS Aug. 1988 149 p
(Contract NCC2-55)
(NASA-CR-184795; NAS 1.26:184795; JIAA-TR-85) Avail: NTIS HC A07/MF A01 CSCL 01A

The effects of leading edge flaps on the aerodynamic characteristics of a low aspect-ratio delta wing are studied theoretically. As an extension of the classical crossflow plane analysis and in order to include separated shear layers, an analogy between three dimensional steady conical and two dimensional unsteady self-similar flows is explored. This analogy provides a simple steady-unsteady relationship. The criteria for the validity of the steady-unsteady analogy are also examined. Two different theoretical techniques are used to represent the separated shear layers based on the steady-unsteady analogy, neglecting the trailing edge effect. In the first approach, each vortex system is represented by a pair of concentrated vortices connected to the separation points by straight feeding sheets. In the second approach, the vortex cloud method is adopted for simulating the flow field in the crossflow plane. The separated shear layers are replaced with a cloud of discrete vortices and the boundary element method is employed to represent the wing trace by a vorticity distribution. A simple merging scheme is used to model the core region of the vortical flow as a single vortex by imposing a restriction on the shear layer rotation angle. The results are compared with experiments and with results from 3-D panel calculations. Author

N89-15894# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
HIGHER-ORDER APPROXIMATIONS IN INTERACTIVE AIRFOIL CALCULATIONS
DAVID WALTER ZINGG Sep. 1988 224 p
(UTIAS-326; ISSN-0082-6255) Avail: NTIS HC A10/MF A01

Cross-stream pressure gradients can be important in the trailing edge region of an airfoil. This thesis presents the development of two interactive airfoil calculation procedures, applicable to fully-attached incompressible flow, which include cross-stream pressure gradients and other higher-order terms in both the turbulent viscous equations and the viscid-inviscid matching conditions. The first procedure utilizes the second-order boundary layer equations and a second-order approximation to the displacement effect matching condition. The second procedure employs the time-averaged Navier-Strokes equations are solved with an implicit finite difference procedure along with an algebraic turbulence model. Solution of the Navier-Stokes equations is accomplished using an iterative marching technique which accounts for the upstream influence of the pressure field only, neglecting the upstream influence due to viscous and turbulent diffusion.
Author

N89-15895*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL DYNAMICS DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR FY 1988 AND PLANS FOR FY 1989
JAMES E. GARDNER Jan. 1989 197 p
(NASA-TM-101543; NAS 1.15:101543) Avail: NTIS HC A09/MF A01 CSCL 20D

The purpose of this paper is to present the Structural Dynamics Division's research accomplishments for FY 1988 and research plans for FY 1989. The work under each Branch (technical area) is described in terms of highlights of accomplishments during the past year and plans for the current year as they relate to five-year plans for each area. This information will be useful in program coordination with other government organizations and industry in areas of mutual interest. Author

N89-15896*# United Technologies Research Center, East Hartford, CT.
AN ANALYSIS FOR HIGH SPEED PROPELLER-NACELLE AERODYNAMIC PERFORMANCE PREDICTION. VOLUME 1: THEORY AND APPLICATION Final Report
T. ALAN EGOLF, OLOF L. ANDERSON, DAVID E. EDWARDS, and ANTON J. LANDGREBE Washington NASA Dec. 1988 261 p
(Contract NAS3-20961; NAS3-22142; NAS3-22257)
(NASA-CR-4199-VOL-1; E-4382; NAS 1.26:4199-VOL-1) Avail: NTIS HC A12/MF A01 CSCL 01A

A computer program, the Propeller Nacelle Aerodynamic Performance Prediction Analysis (PANPER), was developed for the prediction and analysis of the performance and airflow of propeller-nacelle configurations operating over a forward speed range inclusive of high speed flight typical of recent propfan designs. A propeller lifting line, wake program was combined with

a compressible, viscous center body interaction program, originally developed for diffusers, to compute the propeller-nacelle flow field, blade loading distribution, propeller performance, and the nacelle forebody pressure and viscous drag distributions. The computer analysis is applicable to single and coaxial counterrotating propellers. The blade geometries can include spanwise variations in sweep, droop, taper, thickness, and airfoil section type. In the coaxial mode of operation the analysis can treat both equal and unequal blade number and rotational speeds on the propeller disks. The nacelle portion of the analysis can treat both free air and tunnel wall configurations including wall bleed. The analysis was applied to many different sets of flight conditions using selected aerodynamic modeling options. The influence of different propeller nacelle-tunnel wall configurations was studied. Comparisons with available test data for both single and coaxial propeller configurations are presented along with a discussion of the results. Author

N89-15897*# United Technologies Research Center, East Hartford, CT.
AN ANALYSIS FOR HIGH SPEED PROPELLER-NACELLE AERODYNAMIC PERFORMANCE PREDICTION. VOLUME 2: USER'S MANUAL
T. ALAN EGOLF, OLOF L. ANDERSON, DAVID E. EDWARDS, and ANTON J. LANDGREBE Washington NASA Dec. 1988 307 p
(Contract NAS3-20961; NAS3-22142; NAS3-22257)
(NASA-CR-4199-VOL-2; E-4399; NAS 1.26:4199-VOL-2) Avail: NTIS HC A14/MF A01 CSCL 01A

A user's manual for the computer program developed for the prediction of propeller-nacelle aerodynamic performance reported in, An Analysis for High Speed Propeller-Nacelle Aerodynamic Performance Prediction: Volume 1 -- Theory and Application, is presented. The manual describes the computer program mode of operation requirements, input structure, input data requirements and the program output. In addition, it provides the user with documentation of the internal program structure and the software used in the computer program as it relates to the theory presented in Volume 1. Sample input data setups are provided along with selected printout of the program output for one of the sample setups. Author

N89-15898*# City Coll. of the City Univ. of New York. Dept. of Mechanical Engineering.
AN EXPERIMENTAL STUDY OF NEAR WALL FLOW PARAMETERS IN THE BLADE END-WALL CORNER REGION Final Report
RAKESH K. BHARGAVA and RISHI S. RAJ Washington NASA Jan. 1989 314 p
(Contract NAG3-122)
(NASA-CR-4211; E-4506; NAS 1.26:4211) Avail: NTIS HC A14/MF A01 CSCL 01A

The near wall flow parameters in the blade end-wall corner region is investigated. The blade end-wall corner region was simulated by mounting an airfoil section (NACA 65-015 base profile) symmetric blades on both sides of the flat plate with semi-circular leading edge. The initial 7 cm from the leading edge of the flat plate was roughened by gluing No. 4 floor sanding paper to artificially increase the boundary layer thickness on the flat plate. The initial flow conditions of the boundary layer upstream of the corner region are expected to dictate the behavior of flow inside the corner region. Therefore, an experimental investigation was extended to study the combined effect of initial roughness and increased level of free stream turbulence on the development of a 2-D turbulent boundary layer in the absence of the blade. The measurement techniques employed in the present investigation included, the conventional pitot and pitot-static probes, wall taps, the Preston tube, piezoresistive transducer and the normal sensor hot-wire probe. The pitot and pitot-static probes were used to obtain mean velocity profile measurements within the boundary layer. The measurements of mean surface static pressure were obtained with the surface static tube and the conventional wall tap method. The wall shear vector measurements were made with a specially constructed Preston tube. The flush mounted piezoresistive type pressure transducer were employed to measure the wall pressure fluctuation field. The velocity fluctuation measurements, used in obtaining the wall pressure-velocity correlation data, were made with normal single sensor hot-wire probe. At different streamwise stations, in the blade end-wall corner region, the mean values of surface static pressure varied more on the end-wall surface in the corner region were mainly caused by the changes in the curvature of the streamlines. The magnitude of the wall shear stress in the blade end-wall corner region increased significantly in the close vicinity of the corner line. The maximum value of the wall shear stress and its location from the corner line, on both the surfaces forming the corner region, were observed to change along the corner. These observed changes in the maximum values of the wall shear stress and its location from the corner line could be associated with the stretching and attenuation of the horseshoe vortex. The wall shear stress vectors in the blade end-wall corner region were observed to be more skewed on the end-wall surface as compared to that on the blade surface. The differences in the wall shear stress directions obtained with the Preston tube and flow visualization method were within the range in which the Preston tube was found to be insensitive to the yaw angle. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A89-21375
A HISTORICAL REVIEW OF U.S. AIRCRAFT STATISTICS SUGGESTING THE NEED FOR AUTOMATIC FLIGHT PATH RECOVERY SYSTEMS
T. J. MILLER, D. E. PRICE, and M. I. DARRAH (McDonnell Aircraft Co., Saint Louis, MO) SAFE Journal, vol. 18, Winter 1988, p. 14-17.

The growing resort of tactical aircraft to high-speed/low-level, terrain-following/avoiding, all-weather and nocturnal attack operations is projected to significantly increase safety risks for their crews. Risk reduction may be achieved through the careful application of safety engineering to those system elements most likely to precipitate controlled-flight-into-terrain (CFIT) accidents. CFIT-avoiding methods presently suggested include the use of an emergency flight path recovery/ground-proximity warning system, the general reduction of crew workloads, and the design of canopies and windscreens to maximize external visibility. O.C.

A89-22629#
A NOTE ON THE CONTROL AGAINST MICROBURST
HIROKI KUMAGAI and KANICHIRO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 418, 1988, p. 520-528. In Japanese, with abstract in English. refs

Flights against microburst are analyzed as optimal control problems. A typical microburst model is used with a Dryden gust model superimposed on it. Control laws are those of an optimal regulator with Kalman-filter for noisy measurements. The result shows the importance of the accurate measurements of ground and air velocity as well as climb rates. The result also shows a control law which is close to optimal and which is feasible for practical use. Author

A89-23335#
THE ROLE OF MANUFACTURER IN THE ACCIDENT INVESTIGATION
C. ARCARI (Agusta S.p.A., Milan, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 22 p.

The potential role that aircraft manufacturers can play in

identifying the probable causes of accidents is discussed. The sooner the cause is identified, the sooner corrective actions can be taken. Various helicopter accidents are analyzed and possible causes such as improper maintenance and manufacturing problems are identified. K.K.

A89-23375#
CRASHWORTHINESS - A MATURING DISCIPLINE
BRIAN L. CARNELL (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 16 p. refs

The growth of crashworthiness as an engineering discipline in the U.S. is reviewed from its inception in the 1960's to its application to future helicopters. The development of the crashworthiness technology and its application to both old and new military helicopters by the U.S. Army and the U.S. Navy are discussed, with special attention given to the specific crashworthiness design features in the UH-60A Black Hawk utility helicopter and the SH-60B Seahawk helicopter. Attention is also given to the design and test results of the crashworthy crew-seat systems and fuel systems. The crash-attenuating measures recommended by the Crashworthiness Project Group of the Aerospace Industries Association of America are described. I.S.

A89-24374
CHEMICAL HAZARDS IN AEROMEDICAL AIRCRAFT
CHARLES R. TUPPER (USAF, Rhein Main AB, Federal Republic of Germany) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, Jan. 1989, p. 73-75. refs

This paper discusses potential hazards that poisonous substances contained in various aircraft systems, such as the hydraulic fluid, oil products, fire-protection, and ice-protection chemicals, may pose to the crewmembers, patients, or passengers of an aeromedical aircraft. Potential areas for chemical leakage from fuel receptacles and hydraulic reservoirs are identified, and the basic first-aid procedures for treating people contaminated with various hazardous liquids, including jet fuel, hydraulic fluid, engine oil, fire extinguisher agents, and LOX fluids, are described. I.S.

N89-15088# Boeing Advanced Systems Co., Seattle, WA.
ADVANCED AIR SEPARATION MODULE PERFORMANCE EVALUATION Final Report, May 1986 - Sep. 1987
CHARLES L. ANDERSON Jul. 1988 215 p
(Contract F33615-84-C-2431)
(AD-A198401; D180-30946-1; AFWAL-TR-88-2031) Avail: NTIS HC A10/MF A01 CSCL 21D

Results of an experimental performance evaluation of two advanced lightweight permeable membrane (PM) air space modules (ASM) are presented. ASMs produce nitrogen enriched air which is used for airplane fuel tank inerting. The airplane inerting system is termed On-Board Inert Gas Generator System (OBIGGS). ASMs were obtained from two sources: A/G Technology Corp. and Permea Inc. Steady state performance envelope, long term endurance, hot/cold start-up on/off cycling, moisture, vibration, contaminant, and high temperature destructive tests were conducted. Results indicate that a significant breakthrough in OBIGGS weight reduction has been achieved. Both the A/G and Permea ASMs offer significant reductions in weight over present SOTA (state-of-the-art) ASM technology. Performance of the A/G and Permea ASMs is directly compared to other ASM technology in terms of ASM weight as well as total airplane penalties which include bleed air usage and bleed system component weight. Comparisons indicate that the advanced ASMs will allow significant weight reductions in the bleed air system compared to present SOTA ASM technology. This was accomplished by using less bleed air at higher temperatures. Basic ASM performance models are presented along with analysis of ASM moisture sensitivity, pressure drop, and thermal response. GRA

N89-15089# Federal Aviation Administration, Washington, DC.
AIRPORT ACTIVITY STATISTICS OF CERTIFICATED ROUTE AIR CARRIERS
31 Dec. 1987 930 p
(AD-A199186) Avail: NTIS HC A99/MF A02 CSCL 01E

This report furnishes airport activity of the large Certificated Route Air Carriers. Included in the data contained in Table 6 are passenger enplanements, tons of enplaned freight, express, and mail. Both scheduled and non-scheduled service, and domestic and international operations are included. These data are shown by airport and carrier. Table 7 includes departure by airport, carrier and type of operation, and type of aircraft. GRA

N89-15899# Aviation Safety Commission, Washington, DC.
AVIATION SAFETY COMMISSION. VOLUME 1: RECOMMENDATIONS Final Report
18 Apr. 1988 58 p
(PB88-209069) Avail: NTIS HC A04/MF A01; also available SOD HC $3.25 as 022-003-01149-8 CSCL 01C

The Aviation Safety Commission believes that the Federal Government must continue to play the central role in ensuring safe operation of the U.S. aviation system. The Commission's recommendations address in a constructive way all of the issues raised in the current debate and reflect the input the authors have received from the Secretary of Transportation, the FAA, former FAA administrators, Members of Congress, the NTSB, consumers and industry experts. The Aviation Safety Commission also recommends improving aviation safety regarding: Safety inspection; Regional airline safety; General aviation in the air traffic control system; FAA rulemaking; Airport safety and capacity; and Use of operations research. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A89-21176
NAVIGATION - SHIPS TO SPACE
MYRON KAYTON IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 24, Sept. 1988, p. 474-519. refs

An examination is made of old and new navigation technology that considers most factors affecting this technology, including cost, accuracy, autonomy, time-delay, global coverage, and the human interface. The author reviews cartography and the navigation of land, ship, air, and space vehicles, concluding with a forecast of navigation in the 21st century. An extensive annotated bibliography is included. I.E.

A89-21817
PARALLEL RUNWAY OPERATIONS ARE THE KEY TO INCREASING AIRPORT TRAFFIC CAPACITY
GIORA NAGID (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Bulletin (ISSN 0018-8778), vol. 43, Sept. 1988, p. 24-26.

The possible reduction of airport capacity constraints by performing simultaneous operations on parallel runways in instrument meteorological conditions is discussed. Specifications and guidance material for such operations have been developed, including the minimum separation distances between parallel runways. Operational modes for parallel runway operations are described. Previous studies that were reviewed in determining the parallel runway operation specifications are examined. R.B.

A89-22808
GUIDED AROUND THE EARTH BY SATELLITES - EXTREME ACCURACY IN NAVIGATION FROM SPACE [VON SATELLITEN UM DIE ERDE GELEITET - EXTREME

GENAUIGKEIT BEI NAVIGATION AUS DEM ALL]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 9, 4th Quarter, 1988, p. 43-45. In German.

The use of satellite guidance to achieve extreme accuracy in aircraft flight is discussed. The development of such use is reviewed and problems that must be solved to expand this type of guidance are considered. The promise offered by GPS in this area is addressed. C.D.

A89-23358#
AN ANALYTICAL TOOL TO DEFINE CRITERIA FOR HELICOPTER AIRBORNE RADAR APPROACH PROCEDURES TO OFFSHORE INSTALLATIONS
BEN W. G. SCHUTE (Nationaal Lucht- en Ruimtevaalaboratorium, Amsterdam, Netherlands) and HERRY J. KLUMPER (Rijksluchtvaartdienst, Schiphol, Netherlands) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

A mathematical model was developed to define criteria for the airborne radar approach procedure, which is used to obtain the lowest possible weather limits for the approach to offshore installations. This model can be used to determine the position of the missed approach point such that a safe missed approach can be carried out. The outer boundary flight path can be computed taking into account navigation and flight technical errors. K.K.

A89-23819
SATELLITE COMMUNICATIONS FOR AIR TRANSPORT [SATELLITENKOMMUNIKATION FUER DIE LUFTFAHRT]
ANDREAS NEUL and JOACHIM HAGENAUER (DFVLR, Institut fuer Nachrichtentechnik, Oberpfaffenhofen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 56-58. In German.

Technological requirements for a satellite communications system for civil aviation are discussed. The establishment and maintenance of a signal path and modulation procedures for data transmission are addressed. Error correction codes are discussed, and steps to enable digital speech in the system are examined. C.D.

A89-24054
AN ADAPTIVE TRANSMIT POWER CONTROL SYSTEM FOR DIGITAL AIRBORNE COMMUNICATIONS
LAWRENCE L. GUTMAN (USAF, Avionics Laboratory, Wright-Patterson AFB, OH), GLENN E. PRESCOTT, and THOMAS J. KINDEL (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 411-415.

The authors describe a technique for adaptively controlling the transmission power of a digital airborne low-probability-of-intercept (LPI) radio. The purpose of adaptive transmit power control (ATPC) is to reduce and maintain transmit power at the minimum level required for tactical communications among specific aircraft within a 20-km radius. A closed-loop, half-duplex system using an interrogate/transpond operation is suggested as a suitable candidate for the ATPC network. It is determined that the short duration of the interrogation pulse limits its detectability. The interrogation pulse is shown to have approximately a 10-dB advantage over a non-ATPC system transmission of 0.8 (wideband radiometer). I.E.

A89-24070
AUTOMATIC ACQUISITION AND TRACKING FOR LASER COMMUNICATION USING VIDEO TECHNIQUES
G. S. MECHERLE, A. K. RUE, and G. T. POPE (Hughes Aircraft Co., El Segundo, CA) IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 543-555. Research supported by Hughes Aircraft Co.
(Contract F33615-86-C-1073)

The authors discuss automatic tracking laser communication terminals for the Laser Communication Test System (LCTS) at Wright Patterson Air Force Base. The LCTS terminals have established the viability of aircraft laser communication systems using GaAs laser diodes with video tracking/acquisition techniques. Video tracking and automation acquisition have been shown to provide a legitimate alternative to a previously described quadrant detector approach. The LCTS program also proved that a single subsystem, incorporating a CCD video camera, gyrostabilized gimbal and servo electronics, can perform both automatic acquisition to 12-deg of field of regard and precision tracking in support of aircraft laser communication. I.E.

A89-24100
ANTENNA POINTING AND SCANNING CONTROL FOR A TWO AXIS GIMBAL SYSTEM IN THE PRESENCE OF PLATFORM MOTION
P. D. KARABINIS, R. G. EGRI, and C. L. BENNETT (Raytheon Co., Equipment Div., Marlborough, MA) IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 793-799.

Pointing and scanning control algorithms for a two-axis gimbal, inertially stabilized, airborne antenna system are described and evaluated computer simulation. Satisfactory performance is demonstrated in the presence of aircraft maneuvers, with some (expected) degradation for the very-near-zenith antenna states. The antenna scanning algorithm presented is adaptive in its scan rate (to avoid scan distortions due to azimuth rate limiting imposed by the physical antenna system), is simple to implement, and properly accounts for aircraft maneuvering to maintain circular scanning trajectories in inertial space. I.E.

A89-24317#
DEVELOPMENT OF A SIMPLE FLIGHT EXPERIMENT SYSTEM USING A RADIO CONTROLLED RESEARCH AIRPLANE
AKIRA SAKURAI, MANABU MATSUBARA, and NATSUKO KUDO Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Oct. 1988, p. 691-696. In Japanese, with abstract in English. refs

A simple RPRV (Remotely Piloted Research Vehicle) flight experiment system using a radio-controlled glider has been developed together with related airborne and ground data acquisition systems. Model aircraft technology is used for the control uplink, while the airborne data acquisition and downlink system is miniaturized using a single-chip CPU and a micropower VHF transmitter. Simple phototrackers using conventional 35-mm cameras and rotary encoders have been developed. The CG trajectory and the attitude of the RPRV can be determined from analysis of the photographic frames from two of these trackers. Wind sensors atop a 10-m high pole and a hand-held computer for test management and data recording complete the flight test system. C.D.

A89-24318#
PHOTOGRAPHIC ANALYSIS OF THE LOCATION AND THE ATTITUDE OF THE RADIO-CONTROLLED RESEARCH VEHICLE
AKIRA SAKURAI and NATSUKO KUDO Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Oct. 1988, p. 697-703. In Japanese, with abstract in English.

A simple flight experiment system using a radio-controlled glider is being developed. A photographic tracking system using motor-driven 35-mm cameras mounted on gimbals has also been developed. A method of analyzing the photo images taken by these cameras in combination with the gimbal angle data is reported. The aircraft CG trajectory is obtained by triangulation, while its attitude (the Euler angles) is obtained by fitting the observed image coordinates of object points on the aircraft with the model coordinates, which can be calculated using the Euler angles as parameters. Examples of flight test results show that an accuracy of tens of cm is obtained for the CG location, while the Euler angles seem to be accurate within one degree. C.D.

A89-24700
ACTIVE ARRAYS REPLACING ACTIVE RADOMES
BRIAN WANSTALL and MARTIN STREETLY Interavia (ISSN 0020-5168), vol. 44, Jan. 1989, p. 33-38.

The inherent weight and drag penalties of active radomes carried atop AEW aircraft are being precluded in next-generation systems, which will be conformal with fuselage and wing surfaces. For the nearer term, a 40-percent boost in maximum detection range is expected from the U.S.'s AN/APS-145 rotating-antenna AEW radar, whose initial operating date is in late 1990; this design will introduce three pulse-repetition frequencies, in order to improve air target detection in clutter. A three-year, $7.5-million USAF contract has been awarded for a Conformal Array Radar Technology program involving MMIC transmitter/receiver modules. O.C.

A89-24856
ACTIVITIES AND FINDINGS OF THE ICAO SPECIAL COMMITTEE ON FUTURE AIR NAVIGATION SYSTEMS (FANS)
J. S. SMIT (Rijksluchtvaartdienst, The Hague, Netherlands) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 81-90.

The purview of the ICAO's Special Committee on Future Air Navigation Systems extends to the identification and assessment of novel concepts and technologies for commercial aircraft communications, navigation, and surveillance (CNS) systems. It has been determined that the most promising prospects for future CNS lie in the use of satellite technology for ATC activities on a global scale. The Committee has developed the concept of a Required Navigation Performance Capability, in lieu of the mere carriage of specified equipment, as well as the system architecture for aeronautical mobile satellite communications services. O.C.

N89-15092# Federal Aviation Agency, Atlantic City, NJ.
HELIPORT VISUAL APPROACH SURFACE HIGH TEMPERATURE AND HIGH ALTITUDE TEST PLAN Technical Note, Oct. - Dec. 1987
MARVIN S. PLOTKA and ROSANNE M. WEISS Jun. 1988 28 p
(AD-A200027; DOT/FAA/CT-TN88/5) Avail: NTIS HC A03/MF A01 CSCL 01C

The purpose of this test plan on Helicopter Visual Meteorological Conditions (VMC) Clearance project to be conducted at high temperature and high altitude conditions are as follows: (1) The identification of problems to be investigated; (2) The definition of the tasks required to resolve these problems; (3) The development of test procedures; (4) The description of the methodology for data collection, reduction, and analysis; (5) The specification of the required data. The focus of this test is on the issue of airspace requirement and obstruction protection requirements for visual approaches and departures at a heliport. GRA

N89-15093# Federal Aviation Agency, Atlantic City, NJ.
HELIPORT VISUAL APPROACH AND DEPARTURE AIRSPACE TESTS. VOLUME 1: SUMMARY Technical Note, Mar. - Jul. 1987
ROSANNE M. WEISS, CHRISTOPHER J. WOLF, MAUREEN HARRIS, and JAMES TRIANTOS Aug. 1988 39 p
(AD-A200028; DOT/FAA/CT-TN87/40-1) Avail: NTIS HC A03/MF A01 CSCL 01C

During the winter and spring of 1987 flight tests were conducted at the FAA's Technical Center's Concepts Development and Demonstration Heliport at the Atlantic City International Airport, N.J. The purpose of these flights was to examine and validate the current heliport approach/departure surfaces criteria as defined in the heliport Design Guide and to recommend modifications to these surfaces, if appropriate. The flight activities were conducted using aircraft representative of those in the civilian world. Data were collected using approach surfaces of 7.125, 8.00, and 10.00 deg for straight as well as curved path procedures. Also, departure surfaces of 7.125, 10.00, and 12.00 deg for straight and curved path procedures were used. All maneuvers were tracked by ground based tracking systems. This report documents the results of this activity. It describes the flight test and evaluation methodology and addresses technical as well as operational issues. It provides statistical and graphical analysis of pilot performance along with a discussion of pilot subjective opinions concerning the acceptability and perceived workload, safety, and control margins associated with the procedures flown. The results of this work will be considered in the future modifications of the FAA Heliport Design Advisory Circular, AC 150/5390-2. GRA

N89-15095# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Systemtechnik und Navigation.
THE DATA SYSTEM ON BOARD THE DO 228 FOR TESTING NAVIGATION SYSTEMS WITH HIGH ACCURACY
HANS-PETER ZENZ May 1988 73 p In GERMAN; ENGLISH summary
(DFVLR-MITT-88-20; ISSN-0176-7739; ETN-89-93660) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 29 Deutsche marks

The measuring systems (MUDAS) on the test aircraft DO 228, part of an avionics flight evaluation system for testing navigation systems, are described. A digital navigation computer on the aircraft calculates the position and velocity with high accuracy based on the data of an inertial navigation system (INS), a laser tracker, and a tracking radar. The accuracy of the unaided INS (a laser gyro strapdown navigation system) is described, as well as the time delay of the INS data transmission. Using the INS data, the flight dynamics of the DO 228 were investigated. ESA

N89-15096# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.
SIMULATION OF A FUTURE TERMINAL MANEUVERING AREA (TMA) SCENARIO
VOLKMAR ADAM, WILFRIED GERLING, KARLHEINZ HURRASS, ELMAR KLOSTERMANN, and FRED SCHICK Jun. 1988 50 p
(DFVLR-FB-88-33; ISSN-0171-1342; ETN-89-93757) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 18 Deutsche marks

Real time air traffic simulations of a terminal maneuvering area scenario were performed. It was assumed that most of the approaching aircraft use 4D-procedures. Different traffic mixes of 4D-/non-4D-aircraft were investigated. Results indicate that the future 4D environment will be based on an improved communication, navigation, and surveillance system of high accuracy which includes data link components. This system may not necessarily work on a satellite basis. Special features of the 4D environment will be a strategic and tactical control concept together with a high degree of automation. These prerequisites provide for the ability to fly idle descent profiles on accurate horizontal tracks. Holdings will be avoided. Separation will not be a critical factor. Landing rate improves. ESA

N89-15097# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
THE CHALLENGE OF LOWERED VISIBILITY LIMITS FOR PRECISION APPROACH AND LANDING WITH HELICOPTERS
TJ. HOEKSTRA 26 Jul. 1985 37 p
(NLR-MP-87033-U; ETN-89-93883) Avail: NTIS HC A03/MF A01

It is claimed that the relatively favorable low-speed characteristics of helicopters, compared with fixed-wing aircraft, allow reduced visibility limits, without the need for additional equipment. Aspects related to instrument flight are considered and, based on the results of tests carried out elsewhere, a proposal for reduced visibility limits is formulated. Simulator tests should be carried out to substantiate the proposed limits of 100 ft decision height and 300 m runway visual range in a low-risk environment before carrying out flight tests. ESA

N89-15099*# McDonnell-Douglas Corp., Long Beach, CA.
SIMULATED FINAL APPROACH PATH CAPTURES USING THE MICROWAVE LANDING SYSTEM Final Report
J. B. FEATHER Dec. 1988 79 p
(Contract NAS1-18028)
(NASA-CR-181696; NAS 1.26:181696; C1-E42-TN-392) Avail: NTIS HC A05/MF A01 CSCL 17G

Computer simulation results are presented for intercepting final approach paths using various Microwave Landing System (MLS) path capture concepts. This study, conducted under the Advanced Transport Operating System (ATOPS) program, simulated these captures using the MD-80 aircraft as the study model. Several different capture concepts were investigated. Systems that could be retrofitted into existing aircraft with minimum hardware and software changes were considered. An enhanced ILS look-alike capture provided improved tracking performance over conventional ILS without using a full-up path computer. The other concepts used waypoint databases and path computers to provide smart captures. These captures included lateral path intercepts as well as vertical path control. Winds, turbulence, and MLS noise were included in the simulation. In all cases, acceptable tracking errors were obtained during transition to the final approach path. Author

N89-15100# Federal Aviation Agency, Atlantic City, NJ.
CONTROLLER EVALUATION OF INITIAL DATA LINK AIR TRAFFIC CONTROL SERVICES: MINI STUDY 1, VOLUME 1
NICHOLAS J. TALOTTA Sep. 1988 38 p Prepared in cooperation with Mitre Corp., Atlantic City, NJ; and NTI, Inc., Dayton, OH
(Contract T2001B)
(DOT/FAA/CT-88/25-VOL-1) Avail: NTIS HC A03/MF A01

This report gives the results of Ministudy 1, Volume 1. This ministudy was conducted at the FAA Technical Center utilizing the Data Link testbed. Initial Data Link air traffic control services were evaluated under part task simulation conditions in order to identify service delivery methods which optimize controller acceptance, performance and workload. This report delineates the results for the first of two ministudies and a research and development operational evaluation which comprise the Phase 1 Data Link services package. Author

N89-15101# Federal Aviation Agency, Atlantic City, NJ.
CONTROLLER EVALUATION OF INITIAL DATA LINK AIR TRAFFIC CONTROL SERVICES: MINI-STUDY 1, VOLUME 2 Final Report
NICHOLAS J. TALOTTA Sep. 1988 120 p
(Contract T2001B)
(DOT/FAA/CT-88/25-VOL-2) Avail: NTIS HC A06/MF A01

This report gives the results of Ministudy 1, Volume 2. This ministudy was conducted at the FAA Technical Center utilizing the Data Link test bed. Initial Data Link air traffice control services were evaluated under part task simulation conditions in order to identify service delivery methods which optimize controller acceptance, performance, and workload. This report delineates the results for the first of two ministudies and a research and development operational evaluation which comprise the Phase 1 Data Link services package. Author

N89-15900*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PILOTED SIMULATION STUDY OF DATA LINK ATC MESSAGE EXCHANGE
MARVIN C. WALLER and GARY W. LOHR (Embry-Riddle Aeronautical Univ., Daytona Beach, FL.) Washington, DC Feb. 1989 38 p
(NASA-TP-2859; L-16450; NAS 1.60:2859) Avail: NTIS HC A03/MF A01 CSCL 17B

Data link Air Traffic Control (ATC) and Air Traffic Service (ATS) message and data exchange offers the potential benefits of increased flight safety and efficiency by reducing communication errors and allowing more information to be transferred between aircraft and ground facilities. Digital communication also presents an opportunity to relieve the overloading of ATC radio frequencies which hampers message exchange during peak traffic hours in many busy terminal areas. A piloted simulation study to develop pilot factor guidelines and assess potential flight crew benefits and liabilities from using data link ATC message exchange was completed. The data link ATC message exchange concept, implemented on an existing navigation computer Control Display Unit (CDU) required maintaining a voice radio telephone link with an appropriate ATC facility. Flight crew comments, scanning behavior, and measurements of time spent in ATC communication activities for data link ATC message exchange were compared to similar measures for simulated conventional voice radio operations. The results show crew preference for the quieter flight deck environment and a perception of lower communication workload. Author

N89-15901*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATION EVALUATION OF TIMER, A TIME-BASED, TERMINAL AIR TRAFFIC, FLOW-MANAGEMENT CONCEPT
LEONARD CREDEUR and WILLIAM R. CAPRON (PRC Kentron, Inc., Hampton, VA.) Washington, DC Feb. 1989 69 p
(NASA-TP-2870; L-16386; NAS 1.60:2870) Avail: NTIS HC A04/MF A01 CSCL 17G

A description of a time-based, extended terminal area ATC concept called Traffic Intelligence for the Management of Efficient Runway scheduling (TIMER) and the results of a fast-time evaluation are presented. The TIMER concept is intended to bridge the gap between today's ATC system and a future automated time-based ATC system. The TIMER concept integrates en route metering, fuel-efficient cruise and profile descents, terminal time-based sequencing and spacing together with computer-generated controller aids, to improve delivery precision for fuller use of runway capacity. Simulation results identify and show the effects and interactions of such key variables as horizon of control location, delivery time error at both the metering fix and runway threshold, aircraft separation requirements, delay discounting, wind, aircraft heading and speed errors, and knowledge of final approach speed. Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-21407
DEVELOPMENTS AND PERSPECTIVES AT AMD-BA IN THE FIELD OF IMPACT AND CRASH SIZING [DEVELOPPEMENTS ET PERSPECTIVES AUX AMD-BA DANS LE DOMAINE DU DIMENSIONNEMENT AUX IMPACTS ET AU CRASH]
Y. MARTIN-SIEGFRIED (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) (NATO, AGARD, Meeting, Luxembourg, May 2-4, 1988) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 132, 1988, p. 46-53. In French.

Impact and soft crash sizing simulations have been performed using a finite-element global ground-aircraft model. Results are presented for the hard landing of a Mercure aircraft and the soft crash of a Falcon 900 aircraft. The data will be used as input in the dynamic and nonlinear modeling of hard crash problems for commuter-type aircraft such as the Falcon 10. R.R.

A89-21568
CALCULATION OF A MULTISPAR WING BOX WITH ALLOWANCE FOR THE VARIABLE STIFFNESS OF THE LOAD-BEARING ELEMENTS [K RASCHETU KESSONA MNOGOLONZHERONNOGO KRYLA S UCHETOM PEREMENNOI ZHESTKOSTI SILOVYKH ELEMENTOV]

N. S. BULATOV and V. A. KOZLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 75-77. In Russian.

An analytical solution is obtained for the problem of the stress-strain state of the box-type shell of a straight multispar wing. The problem is solved in displacements using the approach proposed by Obraztsov and Onanov (1973). Some numerical results obtained on a computer using the solutions proposed here are presented. V.L.

A89-21569
ANALYSIS OF THE BOX OF A SWEPT WING [K RASCHETU KESSONA STRELOVIDNOGO KRYLA]
A. F. ZAITSEV and P. N. KUROCHKA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 77-79. In Russian. refs

An attempt is made to obtain an analytical solution for a shell characterized by variable stiffness, taper, and multiclosure. The solution is based on the method proposed by Obraztsov (1966) in the context of the engineering theory of thin shells. The variability of the skin thickness and cross-sectional area of the longitudinal assembly leads to a system of resolvent differential equations with variable coefficients. The integration of the equations is carried out using special functions. V.L.

A89-21789
MIG FULCRUM - PINNACLE OF THE LAST GENERATION?
JOHN FRICKER Air International (ISSN 0306-5634), vol. 35, Dec. 1988, p. 281-289, 316.

A design-features and performance-level evaluation is presented for the MiG-29 fighter, with attention to the combat-capability implications of an aerobatic maneuvering display of the aircraft at the 1988 Farnborough air show. It appears that this twin-low bypass turbofan, 10-g stressed airframe fighter is more supersonically maneuverable than the F/A-18, despite the U.S. fighter's use of fly-by-wire and the Soviet fighter's reliance on hydraulic servooperated controls with only conventional stability augmentation. The unique engine inlet employs upper strake-surface louvers that operate during takeoff and landing rolls on improvised airstrips with poor surfaces. Three-view and cutaway drawings of the MiG-29 are presented. O.C.

A89-21845
SKYHAWK SOARS AGAIN
ERIC BEECH and TIM HALL Flight International (ISSN 0015-3710), vol. 134, Dec. 10, 1988, p. 22-27.

An account is given of currently available modifications and retrofittings to the A-4 Skyhawk aircraft that allow it to achieve 90 percent of the capabilities of the F-16 fighter at 25 percent of the F-16's acquisition and maintenance costs. Two such 'updates' of the A-4 are presented: that of the RNZAF, which employs avionics from F-18-class fighter technology and carries such precision-guided weapons as Maverick and Sidewinder, and that of the Singaporean Air Force, which incorporates the state-of-the-art F404-GE-100D low-bypass turbofan in 10,000-lb thrust nonafterburning form to achieve a 15-percent increase in dash speed. The new engine also affords the A-4 superior fuel economy and a factor-of-10 reduction in maintenance manhours per flight-hours. O.C.

A89-22294#
STOVL ENGINE/AIRFRAME INTEGRATION
R. L. BUCKNELL (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 122-125. Previously cited in issue 20, p. 3151, Accession no. A87-45158.

A89-22329
PITCH-FLAP FLUTTER INSTABILITY OF A SWEPT-TIP MODEL ROTOR BLADE
W. R. WALKER and C. HATCH (Royal Aircraft Establishment, Farnborough, England) Vertica (ISSN 0360-5450), vol. 12, no. 3, 1988, p. 293-302. refs

A joint theoretical and experimental investigation into the pitch-flap flutter of a swept-tip model rotor blade is described. The blade tip is swept aft to give a rearward shift of the centers of pressure and mass of the type that could be beneficial in the aeroelastically tailored blade concept. The form of the flutter is identified, as are the parameters which influence it most, and the means used to control the flutter are described. Author

A89-22807
WESTERN TECHNICAL WORLD IMPRESSED BY MIG-29 SHOW - SOVIET FIGHTER AIRCRAFT UNDER THE MAGNIFYING GLASS [WESTLICHE FACHWELT VON MIG-29-SHOW BEEINDRUCKT - SOWJETISCHES KAMPFFLUGZEUG UNTER DIE LUPE GENOMMEN]
OSKAR FRIEDRICH (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 9, 4th Quarter, 1988, p. 16-20. In German.

Details of the Soviet MiG-29 fighter aircraft revealed at an airshow are described. The aircraft's aerodynamic concept, flight performance, steering, and propulsion are examined. The avionics, cockpit, constructional materials, payload, and camouflage against radar and infrared radiation are considered. C.D.

A89-22810#
TAKEOFF DRAG PREDICTION FOR AIRBUS A300-600 AND A310 COMPARED WITH FLIGHT TEST RESULTS
B. HAFTMANN, F.-J. DEBBELER, and H. GIELEN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1398-1412) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1088-1096. Previously cited in issue 24, p. 3543, Accession no. A86-49121.

A89-22817*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PARAMETRIC WEIGHT EVALUATION OF JOINED WINGS BY STRUCTURAL OPTIMIZATION
HIROKAZU MIURA, ALBERT T. SHYU (NASA, Ames Research Center, Moffett Field, CA), and JULIAN WOLKOVITCH (ACA Industries, Inc., Torrance, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1142-1149. refs

Joined-wing aircraft employ tandem wings having positive and negative sweep and dihedral, arranged to form diamond shapes in both plan and front views. An optimization method was applied to study the effects of joined-wing geometry parameters on structural weight. The lightest wings were obtained by increasing dihedral and taper ratio, decreasing sweep and span, increasing fraction of airfoil chord occupied by structural box, and locating the joint inboard of the front wing tip. Author

A89-22818*# Planning Research Corp., Hampton, VA.
INTEGRATING NONLINEAR AERODYNAMIC AND STRUCTURAL ANALYSIS FOR A COMPLETE FIGHTER CONFIGURATION
KENNETH E. TATUM (Planning Research Corp., Hampton, VA) and GARY L. GILES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1150-1156. Previously cited in issue 03, p. 285, Accession no. A88-14252. refs

A89-22975
AIR FORCE, NASA CONDUCT TESTS TO DEFINE FIGHTER AIRCRAFT AGILITY
WILLIAM B. SCOTT (USAF, Edwards AFB, CA) Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, Jan. 9, 1989, p. 45, 47.

The USAF's Flight Test Center and NASA facilities have undertaken flight test programs that attempt to quantify 'transient' and 'functional' types of airframe agility: the former being defined as the nonsteady portion of a maneuver, and the latter as the entire maneuver, encompassing both transient and steady portions. The time required to complete these segments will directly define an aircraft's merit in agility. X-29 and F-16B test aircraft will undertake data-gathering functions for this program, giving attention

to pitch-angle capture, load-factor capture, limiter turning, loaded rolls, level yaws, and deceleration/acceleration. O.C.

A89-22976
NASA/AHS ROTORCRAFT NOISE REDUCTION PROGRAM - ACCOMPLISHMENTS AT SIKORSKY AIRCRAFT
RAJARAMA K. SHENOY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) Vertiflite (ISSN 0042-4455), vol. 35, Jan.-Feb. 1989, p. 68-73.

Helicopter external noise technology development since the initiation of the highly successful NASA/AHS Rotorcraft Noise Reduction program in 1983 is discussed. The effect of various blade tip shapes on two 9.4-ft diameter rotor systems investigated in NASA-Langley's 14 x 22 ft wind tunnel was determined. A noise reduction potential of up to 5 dB in BVI noise levels was demonstrated. Tail rotor noise characteristics, with and without empennage interaction effects, were also studied. K.K.

A89-23002#
ANALYSIS OF PERFORMANCE MEASUREMENTS OF PROPELLER-DRIVEN AIRCRAFT. IV - POWERPLANT CHARACTERISTICS [ANALIZA WYNIKOW POMIAROW OSIAGOW SAMOLOTU SMIGLOWEGO. IV - CHARAKTERYSTYKA ZESPOLU NAPEDOWEGO]
ANDRZEJ KARDYMOWICZ Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, June 1988, p. 9, 10, 15, 16. In Polish.

Results of an investigation of the performance of propeller-driven aircraft are presented. Powerplant characteristics are analyzed, especially, the influence of temperature and humidity on piston-engine characteristics and propeller efficiency. B.J.

A89-23051
FLYING THE XV-15 AND V-22 TILT-ROTORS
MARK LAMBERT Interavia (ISSN 0020-5168), vol. 43, Dec. 1988, p. 1282-1286.

Flight behavior impressions are presented for the two existing tilt-rotor aircraft, as derived from actual flying of the once-developmental XV-15, and operation of an advanced and highly realistic flight simulator for the V-22, which has already entered production. Attention is given to the characteristics of transitioning maneuvers between vertical and horizontal flight, as well as to the cockpit instrumentation of both the XV-15 and V-22 simulator. The V-22's exceptionally refined stability and controllability derive from the use of fly-by-wire cockpit controls. O.C.

A89-23180*# *California Univ., Los Angeles.*
ROTOR BLADE AEROELASTICITY IN FORWARD FLIGHT WITH AN IMPLICIT AERODYNAMIC FORMULATION
R. CELI and P. P. FRIEDMANN (California, University, Los Angeles) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 730-742) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1425-1433. Previously cited in issue 14, p. 2106, Accession no. A87-33725. refs
(Contract NAG2-226)

A89-23192*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NONLINEAR ANALYSIS OF A CANTILEVER BEAM
HOWARD E. HINNANT (NASA, Ames Research Center, Moffett Field, CA; NASA, Langley Research Center, Hampton, VA) and DEWEY H. HODGES (Georgia Institute of Technology, Atlanta, GA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 966-975) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1521-1527. Research supported by Georgia Institute of Technology. Previously cited in issue 14, p. 2106, Accession no. A87-33749. refs

A89-23306*# Massachusetts Inst. of Tech., Cambridge.
THE MEASUREMENT AND CONTROL OF HELICOPTER BLADE MODAL RESPONSE USING BLADE-MOUNTED ACCELEROMETERS
NORMAN D. HAM (MIT, Cambridge, MA), DWIGHT L. BALOUGH, and PETER D. TALBOT (NASA, Ames Research Center, Moffett Field, CA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 9 p. refs
(Contract NCC2-366; NCC2-447)

The measurement of helicopter blade flapping, bending, and lag modal acceleration and displacement response using blade-mounted accelerometers is described. It is shown that knowledge of the blade mode shapes is sufficient to permit separation of the modal contributions to the accelerometer signals using matrix inversion. The application of the Mckillip (1985) filter to the identification of modal rate response is described. Finally, the design of flapping, bending, and lag mode controllers utilizing the conventional mesh plate is presented. The measurement technique is illustrated using flight test results obtained using a Black Hawk helicopter. Author

A89-23308#
THE AIRLOADS ACTING ON HELICOPTER ROTOR WITH COMBINED FLAPWISE BENDING, CHORDWISE BENDING AND TORSION OF TWISTED NONUNIFORM BLADES
TIANEN RUAN (Quanzhou Electric Power School, People's Republic of China), RUIGUANG LI, and XIANJIAN LIU (Chinese Helicopter Research and Development Institute, People's Republic of China) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 41 p. refs

Wake flow and the effect of wake geometries on the helicopter rotor airloads are investigated analytically using the free vortex approach modified to allow for the coupling elastic deformation. The elastic motion equations include coupling conditions at the blade root associated with the chordwise vibration damper, the pitch link stiffness, and the pitch device with friction. A program for determining the rotor blade airloads, the elastic deformation, and the pitch moment is developed, and computed results are compared with test data. V.L.

A89-23310#
DYNAMIC BEHAVIOR OF A COMPOSITE TAIL UNIT FOR EH101
BRUNO MAINO and GIORGIO VIGNATI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 14 p. refs

A scaled down model of the EH101 tail unit was constructed to verify the reliability of the design criteria for the composite structure. The model was subjected to vibration testing to determine its dynamic behavior and to verify its modal characteristics. Details of the experimental procedure and results are discussed, with particular attention given to various methods of excitation. V.L.

A89-23311#
EH 101 MAIN ROTOR HEAD STRUCTURAL AND MATERIAL DEVELOPMENTS
V. CARAMASCHI, E. COLOMBO, M. NEBULONI, D. ROMITI, F. SCAPINELLO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) et al. AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

The design development and structural characteristics of the major components of the EH 101 helicopter main rotor head are discussed. In particular, attention is given to the analysis and testing philosophies followed in the design evolution of composite and metallic components, hub and tension link structural analysis, and usage optimization of materials based on structural and manufacturing requirements. The discussion also covers the use of complete and partial models of complex structures and correlation with experimental data. V.L.

A89-23315#
EH101: LIGHTNING PROTECTION OF COMPOSITE MATERIALS - RESULTS OF PRELIMINARY TESTS ON CFC PANELS
L. LUINI, G. MESCHI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Samarate, Italy), and A. BERTAZZI (Centro Elettrotecnico Sperimentale Italiano, Milan, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 23 p. refs

Research activities relating to the lightning protection of the EH101 helicopter are reviewed. In particular, attention is given to the analysis of the lightning current impact on CFC laminate panels protected by a conductive coating and to the analysis of the behavior of jointed panels when conducting the lightning current. Details of the tests and relevant results are presented. V.L.

A89-23316#
ELECTROMECHANICAL BLADE FOLD SYSTEMS - CURRENT STATUS AND FUTURE DEVELOPMENTS
PIERO BOZZOLA (Microtecnica S.p.A., Turin, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 15 p.

The electromechanical blade fold actuator designed for the Agusta/Westland helicopter EH101 is described. This single-motor multifunction actuator provides both the structural linkage between the rotor and the blade and the folding/spreading and locking/unlocking of the blade. Future applications of blade folding systems are discussed. K.K.

A89-23319*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INVESTIGATION OF GENERIC HUB FAIRING AND PYLON SHAPES TO REDUCE HUB DRAG
ROBERT H. STROUB, LARRY A. YOUNG, DAVID R. GRAHAM (NASA, Ames Research Center, Moffett Field, CA), and ALEXANDER W. LOUIE (Sterling Software, Moffett Field, CA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 17 p. refs

This paper reports investigations of fairing configurations pointed toward substantially reducing hub drag. Experimental investigations have shown the importance of hub-fairing camber,lower-surface curvature, and relative size on the drag. The significance of pylon and hub fairings in combination have also been shown. Model test data presented here documented these findings, and also showed the effect of gaps and hub-fairing inclination angle on drag. From a drag standpoint, the best hub fairing had a circular arc, upper-surface curvature, a flat bottom surface, and 8.75 percent camber. Author

A89-23320#
AEROELASTIC PREDICTION OF ROTOR LOADS IN FORWARD FLIGHT
BERNADETTE PELEAU and DIDIER PETOT (ONERA, Chatillon-sous-Bagneux, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 19 p. refs

A simple and fast method for calculating the forced response of a helicopter blade in forward flight is presented along with results of a flight test. The code is a step by step solution of the aeroelastic equations obtained by coupling the unsteady aerodynamics of the ONERA dynamic stall model with a modal representation of the structure. Theoretical predictions are compared with data from the SA 349 GV helicopter flight tests, and the effect of some of the parameters in the code is examined. V.L.

A89-23322#
VALIDATION OF A MATHEMATICAL MODEL OF THE SEA KING MK50 HELICOPTER USING FLIGHT TRIALS DATA
M. J. WILLIAMS, A. M. ARNEY, R. H. PERRIN, and R. A. FEIK (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

Validation of a mathematical model of a Sea King Mk50 helicopter, by comparing model predictions with flight data, is described. Comparisons of both performance and flight dynamic characteristics show that the model provides an adequate representation of flight characteristics over a range of airspeeds. Some specific deficiencies which remain are noted and summarized. The use of System Identification techniques to investigate model limitations and to develop improved representations of dynamic characteristics is discussed. The approach is illustrated by examples from Sea King flight measurements, including an assessment of the effects of inflow, flapping, and engine dynamics on vertical acceleration response to collective inputs at hover. Author

A89-23323#
COMPARISON WITH FLIGHT DATA OF HOVER PERFORMANCE USING VARIOUS ROTOR WAKE MODELS
K. R. REDDY and N. E. GILBERT (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

The consistency of different methods in predicting hover performance is investigated with emphasis on various wake models providing realistic nonuniform rotor inflow. In particular, performance estimates obtained from three nonuniform wake models and uniform inflow method based on momentum theory are compared with test data for four helicopters. The nonuniform models are shown to provide good results only when certain parameters are adjusted individually for each case. Although the uniform method does provide consistently good results for the cases studied, it does not give good intermediate results, such as blade loading distribution. A strategy based on the use of both uniform and nonuniform methods is suggested. V.L.

A89-23327*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ESTIMATION OF BLADE AIRLOADS FROM ROTOR BLADE BENDING MOMENTS
WILLIAM G. BOUSMAN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 21 p. refs

This paper presents a method for the estimation of blade airloads, based on the measurements of flap bending moments. In this procedure, the blade rotation in vacuum modes is calculated, and the airloads are expressed as an algebraic sum of the mode shapes, modal amplitudes, mass distribution, and frequency properties. The method was validated by comparing the calculated airload distribution with the original wind tunnel measurements which were made using ten modes and twenty measurement stations. Good agreement between the predicted and the measured airloads was found up to 0.90 R, but the agreement degraded towards the blade tip. The method is shown to be quite robust to the type of experimental problems that could be expected to occur in the testing of full-scale and model-scale rotors. I.S.

A89-23328#
THE NH90 EUROPEAN HELICOPTER PROGRAMME
G. BEZIAC (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p.

This paper discusses the results obtained by the Feasibility and Predefinition Study (started on September 1985) of a medium-size helicopter, called NH 90, with special consideration given to the justification of the recommended solutions for the vehicle and its systems. These solutions are based on the technological capabilities in Europe for the next decade and on the assessment of the associated technical risks. Attention is also given to the main naval and tactical missions of the helicopter. Design diagrams of the NH 90 and associated systems are included. I.S.

A89-23333#
ORCHIDEE - ROLE OF THE HELICOPTER WITHIN A COMPLEX SYSTEM

J. L. MASCLE (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 7 p.

This paper describes the approach followed for defining the Orchidee battlefield surveillance system and its air segment in particular. The Orchidee is the main such system which is to be used by the French army in the 1990s, and will provide a global, real-time picture of the deployment and movement of enemy units over the full depth of their lines. It is shown here how the general definition of the helicopter has been established using a functional analysis of system requirements as well as experimental work. The functions considered include surveillance, vulnerability, and operability. The results of an Orchidee demonstration are reviewed, and the technical, organizational, and architectural characteristics of the equipped helicopter are discussed, including mission equipment, basic avionics, and antenna mounting. C.D.

A89-23339#
SIMULATION MODELS FOR OPTIMIZATION OF HELICOPTER TAKEOFF AND LANDING
T. CERBE and G. REICHERT (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 23 p.

Simulation models for determining helicopter takeoff and landing flight paths are analyzed. A variety of parameters are considered, including translational velocity and accelerations, power requirements, flight attitude angles, and control inputs. The models studied include three-dimensional, two-dimensional, quasi-stationary two-dimensional, and quasi-stationary data field simulation models. The results from the models are compared with flight test results and the influence of various parameters on takeoff and landing performances is evaluated. R.B.

A89-23340#
CORRELATION OF GENERALIZED HELICOPTER FLIGHT TEST PERFORMANCE DATA WITH THEORY
K. LIESE, J. RUSSOW, and G. REICHERT (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 19 p. refs

A historical survey of the development of data reduction methods is presented. In the discussion of data reduction, consideration is given to the determination of nondimensional parameters, restriction to hover, and the extension to forward flight with climb and descent. The numerical evaluation of flight test data is addressed as well as the correlation of flight tests and performance calculations. K.K.

A89-23342#
AN EXPERIMENTAL STUDY OF THE AERODYNAMIC CHARACTERISTICS OF THREE MODEL HELICOPTER FUSELAGES
S. R. AHMED and J. AMTSBERG (DFVLR, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 18 p. refs

A 1:7-scale model fuselage with variable rear end was used to generate a streamline unswept rear-end and flat back rear-end helicopter fuselage. It is shown that a major portion of the aerodynamic drag of conventional helicopter fuselages stems from pressure drag. The pressure drag is created by either a 'dead water' type of separation and/or strong longitudinal vortices in the wake. The streamlining through gradual transition of the cross section from the main body to the tail boom led to an overall improvement with regard to lift, pitching, rolling, and yawing moments. K.K.

A89-23345#
NEW AERODYNAMIC ROTOR BLADE DESIGN AT MBB
G. POLZ and D. SCHIMKE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 20 p. refs

A new rotor blade with an advanced aerodynamic and structural design was developed. Of particular importance to the blade layout were a significant reduction in power consumption, a shift of the transonic operational boundaries to higher Mach numbers relative to the standard B0105 rotor blade, and good thrust capability and handling qualities. A model rotor (4 m in diameter) was built and tested in a wind tunnel up to speeds of 300 km/hr, verifying the predicted rotor characteristics for the whole range of speeds and blade loadings. K.K.

A89-23347#
DESIGN AND ANALYSIS OF COMPOSITE HELICOPTER FUSELAGE STRUCTURES
D. MUELLER, R. MUELLER, and R. PFALLER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 23 p.

A comparison is made between composite helicopter fuselage structures and conventional aluminum fuselage structures. Particular attention is given to effects concerning development, manufacturing, and in-flight operation. It is found that a major advantage of composites is the reduction in weight and cost. K.K.

A89-23348#
BO 105 LS - MEET THE HOT AND HIGH CHALLENGE
W. KUCKEIN and H. GLOECKL (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 18 p.

The BO 105 LS, designed for operation at high altitudes and extreme temperature conditions and for improved single-engine performance, is described. Design goals included high commonality with the present BO 105 family, possibility of retrofitting IFR equipment, and vibration limits within the BO 105 CBS range. Particular attention is given to the BO 105 LSA-3 with a maximum takeoff weight of 2600 kg. K.K.

A89-23350#
EH101 GROUND RESONANCE CLEARANCE
A. L. JORDAN (Westland, PLC, Helicopter Div., Yeovil, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 16 p.

The ground-resonance clearance procedure followed for the first prototype EH101 helicopter is discussed. The three steps involved in the procedure include the theoretical analysis of the rotor and the fuselage, an impedance test of the airframe (to check the predictions of undercarriage stiffness and damping), and the actual clearance of the aircraft, achieved by a careful and progressive exploration of the rotor speed, rotor thrust, and the fuselage all-up-weight ranges. The graphs and tables describing the results of these tests are included. I.S.

A89-23352#
ASPECTS AND RESULTS OF PROFILE DEVELOPMENT FOR CIRCULATION CONTROLLED ROTOR SYSTEMS
H. ZIMMER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 20 p. refs
(Contract BMVG-T/RF-41/F0013/G2232)

A profile design for a high-speed circulation controlled helicopter rotor system is described, and wind tunnel test data for a model with three interchangeable COANDA surfaces are shown for the low-speed region. The results demonstrate a considerable improvement in the equivalent lift to drag ratio over known circulation controlled airfoils, particularly for positive angle of attack and high lift coefficients. The application of the development rotor to a high-speed CCR helicopter with a propulsor is discussed. V.L.

A89-23353#
THE GROUND AND FLIGHT TEST PROGRAMME FOR THE EH101
P. G. DUNFORD (Westland Group, PLC, Yeovil, England) and G.

VISMARA (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Samarate, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 16 p.

The development program for the EH101 helicopter is briefly reviewed with emphasis on the overall ground and flight test programs designed to achieve the project objectives. The discussion covers preliminary testing, weapon system development program, testing of mechanical and electrical/avionics systems, and major program milestones. Finally, the current status of the project is summarized. V.L.

A89-23355#
DITCHING AND FLOTATION CHARACTERISTICS OF THE EH101 HELICOPTER
F. T. WILSON and R. C. S. TUCKER (Westland Group, PLC, Yeovil, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p.

The flotation system design philosophy, descent procedures, and ditching and flotation performance of the EH101 helicopter are reviewed. Results of scaled model testing show that the EH101 helicopter has good ditching characteristics both on calm water and at speeds up to 35 Kts (47 Kts in some cases) and in regular head seas with representative winds equivalent to Sea State 4 (civil version) or Sea State 3 (naval version). Flight path analyses indicate that power-off touchdown speeds of around 30 Kts are attainable by following the recommended procedure. Subsequent flotation performance is shown to meet or exceed statutory requirements. V.L.

A89-23366#
THE DETERMINATION OF ROTOR BLADE LOADING FROM MEASURED STRAINS
S. S. LIU and G. A. O. DAVIES (Imperial College of Science and Technology, London, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

An approach to the determination of rotor blade loading from measured strains is proposed which is based on the idea of using the orthogonality of the blade mode shapes (displacement and moments) to solve the inverse problem. The accuracy of the approach depends on the accuracy of measured strains and the number of measured stations, the number of used modes, the accuracy of mode shape and bending mode calculation, and the accuracy of the orthogonality analysis. The approach is demonstrated for a simple uniform hingeless rotor blade. V.L.

A89-23367#
THE PREDICTION OF ROTOR BLADE STRESSES BY THE RAE/WHL COUPLED MODES ANALYSIS
C. YOUNG (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 49 p. refs

Methods developed in the UK for predicting control system loads, airloads, and stresses on a helicopter rotor blade are reviewed. One of such methods is demonstrated by applying it to the prediction of the blade stress on five different rotor systems at both model and full scale. The configurations discussed are the Puma main rotor fitted with standard swept tip blades, the SA349/2 research Gazelle main rotor, and a split load path model rotor fitted with rectangular and swept tip blades. The predictions of the analysis are compared with measurements from flight tests, and improvements to the method aimed at achieving more accurate predictions are discussed. V.L.

A89-23369#
FURTHER EXPERIENCE WITH A NEW APPROACH TO HELICOPTER AEROELASTICITY
G. T. S. DONE (City University, London, England), P. T. W. JUGGINS (Westland Helicopters, Ltd., Yeovil, England), and M. H. PATEL (Garrad-Hassan, Ltd., London, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 18 p. Research supported by the Ministry of Defence. refs

Further experience with an alternative procedure for computing the aeroelastic stability of a helicopter is described. The basic method has been previously presented and is aimed at generating the coefficients of the aeroelastic equations of motion automatically on a computer. A series of exercises has been undertaken with the objective of verifying the computer program, and the first group of these has been previously reported. This paper describes the remaining exercises and covers air resonance in forward flight, transmission system and fuselage flexibility, and nonhomogeneity of the main rotor control jack stiffnesses. Author

A89-23371#
PANTHER, A DAUPHIN WARRIOR
J. C. LEYSSIEUX and M. LAFARGUE (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 14 p.

This paper describes the salient features of the SA 365 M Panther, a multimission combat helicopter derived from the Dauphin helicopter family. Attention is given to the Panther's primary missions (which include commando tactical transport, fire control, and antitank warfare), and to the special technical design adaptations made for these military missions. Particular consideration is given to the cockpit and the avionics and to the issues of maneuverability and performance. Design diagrams are included. I.S.

A89-23372#
LIGHT HELICOPTER TECHNOLOGY FOR THE YEAR 2000
A. H. LOGAN (McDonnell Douglas Helicopter Co., Mesa, AZ) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 20 p.

Developments in light helicopter technology and the applications of these developments are reviewed. Developments in the configurations, structures, systems, noise reduction, capability, reliability, and maintainability are discussed. It is suggested that the application of thermoplastic and thermoset materials could result in structural weight reductions of about 20 pct. It is found that systems such as the No Tail Rotor concept and the Helicopter Advanced Rotor Program could increase reliability and quality. Also, the application of configuration concepts and advanced materials to reduce the required maintenance is considered. R.B.

A89-23373#
APPLICATION OF NUMERICAL OPTIMIZATION METHODS IN HELICOPTER INDUSTRY
D. BANERJEE and P. SHANTHAKUMARAN (McDonnell Douglas Helicopter Co., Mesa, AZ) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 38 p. refs

In the present numerical optimization methodology for helicopter design, a two-level approach is used which encompasses global and local considerations. At the global level, a helicopters' overall configuration is optimized to meet mission requirements; at the local level, the primary components are optimized to meet their specific design requirements. Illustrative optimizations are presented for (1) the blade airfoil, to improve performance; (2) rotor blade geometry, to improve both hover and forward flight performance; (3) aeroelastic tailored blade structural properties, to generate 'compliant rotor' performance; (4) fuselage structure, to minimize weight and reduce vibration levels; and (5) structurally tailored bearingless rotor hubs, to minimize stresses. O.C.

A89-23376#
EFFECTS OF TWIST ON HELICOPTER PERFORMANCE AND VIBRATORY LOADS
CHARLES KEYS, FRANK TARZANIN, and FRANK MCHUGH (Boeing Helicopter Co., Philadelphia, PA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 11 p. refs

High twist is desirable to provide improved hover, vertical climb and nap-of-the-earth performance capability; however, the high negative angles of attack encountered on the advancing blade tip can adversely affect forward flight performance and vibratory loads. To quantify these effects, a 10 ft diameter model rotor was

evaluated in the Boeing Vertol low speed wind tunnel. This paper summarizes the test results and makes comparisons with theoretical predictions. Author

A89-23377#
ADVANCED DIAGNOSTICS FOR HELICOPTER ROTOR HEAD MANAGEMENT, INCLUDING THE USE OF EXPERT SYSTEMS
I. C. CHEESEMAN (Stewart Hughes, Ltd., Southampton, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 10 p. refs

This paper considers the type of faults that may develop in the rotating blades, the hub, and the control system of a helicopter rotor, together with techniques used to detect information on such faults. Particular attention is given to the application of AI to diagnostic problems. An example is presented, demonstrating that particular IR vibration and blade symptoms arising from various types of rotor irregularities (such as a spanwise or a chordwise mass imbalance, track rod error, blade tab error, or a lag damper fault) could be diagnosed by an expert system during a ground run/hover test, with the system providing a list of unique set of symptoms for the identification of each fault. A flowchart of the EXPROT-PC helicopter rotor expert system is included. I.S.

A89-23380#
EXPERIMENTAL EVALUATION OF LIGHTNING-INDUCED TRANSIENTS ON THE AS355 HELICOPTER
M. ASSELINEAU (Toulouse, Centre d'Essais Aeronautiques, France) and F. GADAL (SEFTIM, Vincennes, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 8 p.

This paper presents the results of experimental evaluation of lightning-induced effects in various structures and systems of an AS355 helicopter. The test setup and measuring apparatus are described along with the parameters measured and the results obtained. The test shows that it is possible to measure the lightning-caused disturbances on the wiring and demonstrates the attenuation provided by a shield. I.S.

A89-24306*# Astron Research and Engineering, Santa Monica, CA.
MEASUREMENTS OF PROPELLER NOISE IN A LIGHT TURBOPROP AIRPLANE
J. F. WILBY and E. G. WILBY (Astron Research and Engineering, Santa Monica, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 40-47. Research supported by NASA. Previously cited in issue 04, p. 440, Accession no. A88-16575. refs

A89-24527
AIRCRAFT CRUISE PERFORMANCE OPTIMIZATION USING CHATTERING CONTROLS
P. BHARDWAJ, H. J. KELLEY, and E. M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 8. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 175-180. refs

Aircraft cruise performance is examined using energy-state approximation and chattering controls to investigate fuel-range optimal trajectories. Classical steady-state cruise, simple chattering cruise, and extended chattering cruise models are studied as constrained parameter-optimization problems. The term extended chattering refers to vehicle system modeling extended to maintain vertical equilibrium only on the average. Computational results are presented for three different aircraft. This study shows that simple chattering cruise for certain specific energies can result in substantial fuel savings over classical steady-state cruise. However, extended chattering cruise results in only marginal fuel savings when compared to simple chattering cruise. Author

A89-24699
WOBBLY GOBLIN - NOT PERFECT BUT FIRST
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 44, Jan. 1989, p. 28-30.

USAF's F-117A 'stealth' fighter embodies a breakthrough in the field of radar cross section control and minimization: a 'faceting' of its surface panels into small, perfectly flat surfaces allows the energy of incident radar illumination waves to be split into numerous, intrinsically weaker lobes. IR and acoustic emission suppression, propulsion smoke and contrail prevention, and visibility reduction are additional disciplines applied to this configuration's design; the present analysis of its aerodynamic consequences concludes that the operational envelope is entirely subsonic. A total of 59 of these aircraft have been procured. O.C.

N89-15102 Cranfield Inst. of Tech., Bedford (England).
DEVELOPMENT OF AN AIRCRAFT DESIGN EXPERT SYSTEM Ph.D. Thesis
J. ALSINA 1988 212 p
Avail: Univ. Microfilms Order No. BRDX82198

The aircraft design process is characterized by the application of a wide range of knowledge across many disciplines based upon a certain degree of judgment and experience of the designer. A two pass approach was taken towards the development of an aircraft design expert system based on the requirements of two conceptually different design steps namely, wing design and aircraft configuration. The current status of the work is one where an actual program for wing design exists with supporting documentation, and a very effective examination of the knowledge base performed based on the detail investigation of the overall aircraft design process with particular emphasis on the wing design and the aircraft configuration design steps. The approach taken accomplishes the objectives of the current research in defining the knowledge base, providing the tools and specifications for tools to be used within an aircraft design expert system closely following the problem-solving techniques utilized by the design expert. Dissert. Abstr.

N89-15104# Honeywell Systems and Research Center, Minneapolis, MN.
DISPLAY SYSTEMS DYNAMICS REQUIREMENTS FOR FLYING QUALITIES Final Report, Oct. 1986 - Dec. 1987
KEVIN BOETTCHER, DAVID K. SCHMIDT, and LORI CASE 9 May 1988 188 p
(Contract F33615-86-C-3615)
(AD-A198275; REPT-88SRC12; AFWAL-TR-88-3017) Avail: NTIS HC A09/MF A01 CSCL 23B

This report summarizes research performed to develop a methodology for deciding requirements for display dynamics that ensure good flying qualities. To this end, a model-based approach was pursued that uses the optimal control model (OCM) of human operator behavior. One aspect of the investigation was to further establish the utility of the OCM in this context by correlating model-based quantities with flying qualities data from existing data bases. Another aspect was to consider how various factors at the pilot/display interface map into usual OCM perceptual parameters. A third element of the investigation was to examine the specific case of an STOL vehicle in an approach and landing configuration, with an explicity modeled processing delay in the HUD. This case study showed the negative impact of the delay and demonstrated how the introduction of additional display dynamics can compensate for its effect. Finally, a methodology for deciding display dynamics requirements has been suggested that is based on multivariable control theory, specifically the structured singular value. The methodology provides a means for assessing robustness of system performance and pilot workload to variations in pilot behavior and with respect to variable aircraft dynamics. It also incorporates a synthesis procedure that selects display dynamics so that a balance is achieved between optimal performance and adequate robustness. GRA

N89-15105# Aeronautical Systems Div., Wright-Patterson AFB, OH. Human Factors Branch.
F-16 AI/VVI (ATTITUDE INDICATORS/VERTICAL VELOCITY INDICATORS) EVALUATION: A COMPARISON OF FOUR CONFIGURATIONS Final Report, Apr. - Jun. 1987
R. A. DUDLEY, J. A. HASSOUN, J. M. GAVERN, P. B. LOVERING,

and M. C. REYNOLDS (Midwest Systems Research, Inc., Dayton, OH.) Aug. 1988 66 p
(AD-A199543; ASD-TR-88-5028) Avail: NTIS HC A04/MF A01 CSCL 01C

The experiment evaluated the effects of four different F-16C cockpit configurations on pilot's objective, subjective, and physiological responses in a simulated Instrument Landing System (ILS) approach. The four configurations were displayed by combining one of two Attitude Indicators (AI) and one of two Vertical Velocity Indicators (VVI). Following is a list of the four instruments: An AI with raw ILS data, an AI with Flight Director steering, a moving pointer VVI, and an improved tape VVI. Seven pilots flew 40 simulated ILS approaches each. Both performance and subjective data were in agreement in suggesting less pilot workload when the aircraft was equipped with Flight Director AI. The results were not conclusive in selecting one VVI over the other. However, it appears that a configuration on an AI with Flight Director steering commands along with a moving pointer VVI could lead to most efficient ILS approach performance.

GRA

N89-15106*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Aerospace Engineering.
HIGH ALPHA FEEDBACK CONTROL FOR AGILE HALF-LOOP MANEUVERS OF THE F-18 AIRPLANE Final Technical Report, Apr. - Dec. 1988
HAROLD STALFORD Dec. 1988 10 p
(Contract NAG1-873)
(NASA-CR-181360; NAS 1.26:181360) Avail: NTIS HC A02/MF A01 CSCL 01C

A nonlinear feedback control law for the F/A-18 airplane that provides time-optimal or agile maneuvering of the half-loop maneuver at high angles of attack is given. The feedback control law was developed using the mathematical approach of singular perturbations, in which the control devices considered were conventional aerodynamic control surfaces and thrusting. The derived nonlinear control law was used to simulate F/A-18 half-loop maneuvers. The simulated results at Mach 0.6 and 0.9 compared well with pilot simulations conducted at NASA. Author

N89-15107*# Sverdrup Technology, Inc., Cleveland, OH.
HASA: HYPERSONIC AEROSPACE SIZING ANALYSIS FOR THE PRELIMINARY DESIGN OF AEROSPACE VEHICLES Final Contractor Report
GARY J. HARLOFF and BRIAN M. BERKOWITZ Nov. 1988 60 p
(Contract NAS3-24105)
(NASA-CR-182226; E-4496; NAS 1.26:182226) Avail: NTIS HC A04/MF A01 CSCL 01C

A review of the hypersonic literature indicated that a general weight and sizing analysis was not available for hypersonic orbital, transport, and fighter vehicles. The objective here is to develop such a method for the preliminary design of aerospace vehicles. This report describes the developed methodology and provides examples to illustrate the model, entitled the Hypersonic Aerospace Sizing Analysis (HASA). It can be used to predict the size and weight of hypersonic single-stage and two-stage-to-orbit vehicles and transports, and is also relevant for supersonic transports. HASA is a sizing analysis that determines vehicle length and volume, consistent with body, fuel, structural, and payload weights. The vehicle component weights are obtained from statistical equations for the body, wing, tail, thermal protection system, landing gear, thrust structure, engine, fuel tank, hydraulic system, avionics, electral system, equipment payload, and propellant. Sample size and weight predictions are given for the Space Shuttle orbiter and other proposed vehicles, including four hypersonic transports, a Mach 6 fighter, a supersonic transport (SST), a single-stage-to-orbit (SSTO) vehicle, a two-stage Space Shuttle with a booster and an orbiter, and two methane-fueled vehicles.

Author

N89-15108*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INITIATIVE IN MULTIDISCIPLINARY OPTIMIZATION OF ROTORCRAFT
HOWARD M. ADELMAN and WAYNE R. MANTAY (Army Aviation Systems Command, Hampton, VA.) Oct. 1988 37 p Presented at the 2nd NASA/AF Symposium on Recent Advances in Multidisciplinary Analysis and Optimization, Hampton, VA, 28-30 Sep. 1988
(NASA-TM-101523; NAS 1.15:101523; AVSCOM-TM-88-B-016)
Avail: NTIS HC A03/MF A01 CSCL 01C

Described is a joint NASA/Army initiative at the Langley Research Center to develop optimization procedures aimed at improving the rotor blade design process by integrating appropriate disciplines and accounting for important interactions among the disciplines. The activity is being guided by a Steering Committee made up of key NASA and Army researchers and managers. The committee, which has been named IRASC (Integrated Rotorcraft Analysis Steering Committee), has defined two principal foci for the activity: a white paper which sets forth the goals and plans of the effort; and a rotor design project which will validate the basic constituents, as well as the overall design methodology for multidisciplinary optimization. The paper describes the optimization formulation in terms of the objective function, design variables, and constraints. Additionally, some of the analysis aspects are discussed and an initial attempt at defining the interdisciplinary couplings is summarized. At this writing, some significant progress has been made, principally in the areas of single discipline optimization. Results are given which represent accomplishments in rotor aerodynamic performance optimization for minimum hover horsepower, rotor dynamic optimization for vibration reduction, and rotor structural optimization for minimum weight. Author

N89-15110*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL OPTIMIZATION OF ROTOR BLADES WITH INTEGRATED DYNAMICS AND AERODYNAMICS
ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA.) and JOANNE L. WALSH Oct. 1988 26 p Presented at the 2nd NASA/Air Force Symposium on Recent Advances in Multidisciplinary Analysis and Optimization, Hampton, VA, 28-30 Sep. 1988
(NASA-TM-101512; NAS 1.15:101512) Avail: NTIS HC A03/MF A01 CSCL 01C

The problem of structural optimization of helicopter rotor blades with integrated dynamic and aerodynamic design considerations is addressed. Results of recent optimization work on rotor blades for minimum weight with constraints on multiple coupled natural flap-lag frequencies, blade autorotational inertia and centrifugal stress has been reviewed. A strategy has been defined for the ongoing activities in the integrated dynamic/aerodynamic optimization of rotor blades. As a first step, the integrated dynamic/airload optimization problem has been formulated. To calculate system sensitivity derivatives necessary for the optimization recently developed, Global Sensitivity Equations (GSE) are being investigated. A need for multiple objective functions for the integrated optimization problem has been demonstrated and various techniques for solving the multiple objective function optimization are being investigated. The method called the Global Criteria Approach has been applied to a test problem with the blade in vacuum and the blade weight and the centrifugal stress as the multiple objectives. The results indicate that the method is quite effective in solving optimization problems with conflicting objective functions. Author

N89-15903 Cranfield Inst. of Tech., Bedford (England).
ANALYTICAL WING WEIGHT PREDICTION/ESTIMATION USING COMPUTER BASED DESIGN TECHNIQUES Ph.D. Thesis
N. A. D. MURPHY 1987 312 p
Avail: Univ. Microfilms Order No. BRDX82210

Every pilot knows that the size and position of masses in an aircraft has a fundamental effect on its performance. The

philosophy behind the progressive evolution of the aircraft geometry and packaging modules from the baseline configuration is explained in detail. The development of detailed modules for the estimation of the aircraft aerodynamics and performance is then presented. A full description of the investigations into the effects of canard-delta interference on the aircraft aerodynamics, is also included. The mathematical content of the aircraft geometry, packaging, aerodynamics and performance modules is presented separately in the appendices, in greater detail. The development and architecture of the Design Synthesis and graphics programs are fully presented and the program operation is described with the aid of flowcharts. A comprehensive user's manual and a design example are also provided. Dissert. Abstr.

N89-15904 Glasgow Univ. (Scotland).
NUMERICAL METHODS FOR THE DESIGN AND UNSTEADY ANALYSIS OF AEROFOILS Ph.D. Thesis
MARCO VEZZA 1986 134 p
Avail: Univ. Microfilms Order No. BRDX81920

A number of new numerical panel methods have been developed which form the basis of a design and analysis package that is particularly applicable to airfoils undergoing unsteady motion in incompressible flow. This research was directed towards the development of methods for predicting unsteady flows about an airfoil. A new method is presented for modeling unsteady, attached, potential flow. A solution is obtained at prescribed times from a linear system of equations, and circulation is shed from the trailing edge in accordance with Kelvin's theorem. The vortex wake is represented by a system of discrete vortices which convect with the fluid particles to which they are attached. Results are presented which illustrate certain characteristics of unsteady, attached flow. Dissert. Abstr.

N89-15905*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF THE EFFECT OF SPANWISE CURVATURE ON WING FLUTTER AT MACH NUMBER OF 0.7
JOSE A. RIVERA, JR. Washington, DC Feb. 1989 28 p
(NASA-TM-4094; L-16291; NAS 1.15:4094) Avail: NTIS HC A03/MF A01 CSCL 01C

An experimental and analytical study was conducted at Mach 0.7 to investigate the effects of spanwise curvature on flutter. Two series of rectangular planform wings of aspect ration 1.5 and curvature ranging from zero (uncurved) to 1.04/ft were flutter tested in the NASA Langley Transonic Dynamics Tunnel (TDT). One series consisted of models with a NACA 65 A010 airfoil section and the other of flat plate cross section models. Flutter analyses were conducted for correlation with the experimental results by using structural finite element methods to perform vibration analysis and two aerodynamic theories to obtain unsteady aerodynamic load calculations. The experimental results showed that for one series of models the flutter dynamic pressure increased significantly with curvature while for the other series of models the flutter dynamic pressure decreased with curvature. The flutter analyses, which generally predicted the experimental results, indicated that the difference in behavior of the two series of models was primarily due to differences in their structural properties. Author

N89-15906# Naval Academy, Annapolis, MD.
PREDICTION OF HELICOPTER FREE FLIGHT TRIM USING A STATE-OF-THE-ART ANALYTICAL MODEL Final Report, 1977 - 1988
GLEN W. PENDRICK 18 Jul. 1988 65 p
(AD-A200404; AD-E900797; USNA-TSPR-152) Avail: NTIS HC A04/MF A01 CSCL 01A

To aid in the design and analysis of rotors, a reliable and efficient code of aircraft aerodynamics is required. With such a code, expensive flight test time may be optimized. A reliable code also allows the engineer to determine the relationship between full scale wind tunnel tests and free flight. In this report, the research code CAMRAD, Comprehensive Analytical Model of Rotocraft Aerodynamics and Dynamics, is investigated to determine if it can be relied upon to construct a free flight test matrix for the prototype Boeing Vertol Helicopter Model 360. Excellent correlation was found between CAMRAD'S wind tunnel analysis and testing data on the Model 360 in the Duits-Nederlandse Windtunnel (DNW) for forward flight conditions from the DNW. The free flight analysis on CAMRAD compared well to theoretical helicopter aerodynamics. A free flight test matrix was constructed from the CAMRAD simulation. GRA

N89-15907*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
AIRCRAFT INTEGRATED DESIGN AND ANALYSIS: A CLASSROOM EXPERIENCE
TERRENCE A. WEISSHAAR 8 Feb. 1989 23 p
(Contract NGT-21-002-080; NGT-80001)
(NASA-CR-184719; NAS 1.26:184719) Avail: NTIS HC A03/MF A01 CSCL 01C

AAE 451 is the capstone course required of all senior undergraduates in the School of Aeronautics and Astronautics at Purdue University. During the past year the first steps of a long evolutionary process were taken to change the content and expectations of this course. These changes are the result of the availability of advanced computational capabilities and sophisticated electronic media availability at Purdue. This presentation will describe both the long range objectives and this year's experience using the High Speed Commercial Transport design, the AIAA Long Duration Aircraft design and RPV design proposal as project objectives. The central goal of these efforts is to provide a user-friendly, computer-software-based environment to supplement traditional design course methodology. The Purdue University Computer Center (PUCC), the Engineering Computer Network (ECN) and stand-alone PC's are being used for this development. This year's accomplishments center primarily on aerodynamics software obtained from NASA/Langley and its integration into the classroom. Word processor capability for oral and written work and computer graphics were also blended into the course. A total of ten HSCT designs were generated, ranging from twin-fuselage aircraft, forward swept wing aircraft to the more traditional delta and double-delta wing aircraft. Four Long Duration Aircraft designs were submitted, together with one RPV design tailored for photographic surveillance. Author

N89-15908*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
MEASURED AND PREDICTED PRESSURE DISTRIBUTIONS ON THE AFTI/F-111 MISSION ADAPTIVE WING
LANNIE D. WEBB, WILLIAM E. MCCAIN, and LUCINDA A. ROSE (PRC Systems Services Co., Edwards, CA.) Nov. 1988 20 p Presented at the 6th Applied Aerodynamics Conference, Williamsburg, VA, 6-8 Jun. 1988
(NASA-TM-100443; H-1495; NAS 1.15:100443; AIAA-88-2555)
Avail: NTIS HC A03/MF A01 CSCL 01C

Flight tests have been conducted using an F-111 aircraft modified with a mission adaptive wing (MAW). The MAW has variable-camber leading and trailing edge surfaces that can change the wing camber in flight, while preserving smooth upper surface contours. This paper contains wing surface pressure measurements obtained during flight tests at Dryden Flight Research Facility of NASA Ames Research Center. Upper and lower surface steady pressure distributions were measured along four streamwise rows of static pressure orifices on the right wing for a leading-edge sweep angle of 26 deg. The airplane, wing, instrumentation, and test conditions are discussed. Steady pressure results are presented for selected wing camber deflections flown at subsonic Mach numbers up to 0.90 and an angle-of-attack range of 5 to 12 deg. The Reynolds number was 26 million, based on the mean aerodynamic chord. The MAW flight data are compared to MAW wind tunnel data, transonic aircraft technology (TACT) flight data, and predicted pressure distributions. The results provide a unique database for a smooth, variable-camber, advanced supercritical wing. Author

N89-15909*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
GROUND VIBRATION TEST RESULTS OF A JETSTAR AIRPLANE USING IMPULSIVE SINE EXCITATION
MICHAEL W. KEHOE and DAVID F. VORACEK Feb. 1989 14 p Presented at the 7th International Modal Analysis Conference, Las Vegas, NV, 30 Jan. - 2 Feb. 1989
(NASA-TM-100448; H-1504; NAS 1.15:100448) Avail: NTIS HC A03/MF A01 CSCL 01C

Structural excitation is important for both ground vibration and flight flutter testing. The structural responses caused by this excitation are analyzed to determine frequency, damping, and mode shape information. Many excitation waveforms have been used throughout the years. The use of impulsive sine (sin omega t)/omega t as an excitation waveform for ground vibration testing and the advantages of using this waveform for flight flutter testing are discussed. The ground vibration test results of a modified JetStar airplane using impulsive sine as an excitation waveform are compared with the test results of the same airplane using multiple-input random excitation. The results indicated that the structure was sufficiently excited using the impulsive sine waveform. Comparisons of input force spectrums, mode shape plots, and frequency and damping values for the two methods of excitation are presented. Author

N89-15910*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT TEST EXPERIENCE AND CONTROLLED IMPACT OF A REMOTELY PILOTED JET TRANSPORT AIRCRAFT
TIMOTHY W. HORTON and ROBERT W. KEMPEL Nov. 1988 44 p
(NASA-TM-4084; H-1447; NAS 1.15:4084) Avail: NTIS HC A03/MF A01 CSCL 01C

The Dryden Flight Research Center Facility of NASA Ames Research Center (Ames-Dryden) and the FAA conducted the controlled impact demonstration (CID) program using a large, four-engine, remotely piloted jet transport airplane. Closed-loop primary flight was controlled through the existing onboard PB-20D autopilot which had been modified for the CID program. Uplink commands were sent from a ground-based cockpit and digital computer in conjunction with an up-down telemetry link. These uplink commands were received aboard the airplane and transferred through uplink interface systems to the modified PB-20D autopilot. Both proportional and discrete commands were produced by the ground system. Prior to flight tests, extensive simulation was conducted during the development of ground-based digital control laws. The control laws included primary control, secondary control, and racetrack and final approach guidance. Extensive ground checks were performed on all remotely piloted systems; however, piloted flight tests were the primary method and validation of control law concepts developed from simulation. The design, development, and flight testing of control laws and systems required to accomplish the remotely piloted mission are discussed.
Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-20837
DITHERED RING LASER GYROS FOR ANGULAR RATE STABILIZATION OF TRACKING SYSTEMS
ARTHUR F. HAYES (Honeywell Systems and Research Center, Minneapolis, MN) IN: Guidance and control 1988; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 30-Feb. 3, 1988. San Diego, CA, Univelt, Inc., 1988, p. 133-153.
(AAS PAPER 88-014)

Analyses and computer simulation results are presented for ring laser gyro (RLG) stabilization of a tracker loop. An RLG is used for the rate sensor in a hypothetical tracker loop. Both a dither stripper and a simple dither filter software algorithm operating at twice the dither frequency are described. It is shown that RLG dither is not a problem if gyro outputs are properly processed.
K.K.

A89-21287
TEST BED FOR THE FLIGHT DATA RECORDER MSRP-12-96 [PRUEFGERAET FUER FLUGDATENSCHREIBER MSRP-12-96]
HARRY KOWALSKI (Interflug Gesellschaft fuer internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 5, 1988, p. 165, 166. In German.

A new device for recording various flight data, the MSRP-12-26, is described. The working principle of the device, its control apparatus, the input, and the processing part of the device are examined. A block diagram of the device is shown. C.D.

A89-21818
PASSIVE TCAS IS UNDERGOING EVALUATION
RICHARD W. GROUX ICAO Bulletin (ISSN 0018-8778), vol. 43, Sept. 1988, p. 27-29.

The development and testing of a passive traffic alert and collision avoidance system (TCAS) is discussed. The passive TCAS detects and processes existing ground-based SSR radar signals. The associated transponder replies to determine relative position, track, and altitude of intruder aircraft within a 32-km range. The characteristics and requirements of the passive system and plans for flight tests are examined. R.B.

A89-23317#
WIDE BAND LASER WARNING RECEIVER FOR HELICOPTERS
F. BIDA and G. BROGI (Sistel S.p.A., Rome, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 24 p.

General operational requirements for laser warning receivers are briefly examined by analyzing typical laser threats and target aiming conditions. The requirements include wide angular coverage, wide spectral response, adequate sensitivity and dynamic range, adequate angular resolution, PRF evaluation capability, and high reliability. Other considerations include minimum weight, limited volume, RWR integrability and cost. The general design and performance characteristics of a prototype laser warning receiver system are then discussed with reference to laboratory, field, and flight tests. V.L.

A89-23325#
AUTOMATIC FLIGHT CONTROL SYSTEM DEVELOPED FOR AB212 'COMBAT S.A.R. HELICOPTER' OF THE ITALIAN AIR FORCE AND FOR AB412 'CARABINIERI'
B. BELLUCCI and B. PAGGI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Saramate, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 26 p.

The operation, equipment, and typical flight applications of an automatic microprocessor-based flight control system SPZ-7300, developed for the AB212 and AB412 helicopters are discussed. The features of the SPZ-7300 include a complete four-axis stability augmentation system/autopilot, duplex for safety, three-cue attitude director indicators, automatic preflight and test, and system diagnostics. The pilot interface with the SPZ-7300 system is through the helicopter controller and flight director mode selector. These units provide complete mode selection, engage functions, and coupling control for the system. I.S.

A89-23334#
DIGITAL AFCS FOR AS 332 MK II HELICOPTER
A. VAISSIERE (Societe de Fabrication d'Instruments de Mesure, Massy, France) and E. WOIRIN (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 8 p.

The new AS 332 MK II helicopter will soon be flight-tested with a digital Automatic Flight Control System (AFCS). The development of the digital AFCS is reviewed, and the main AFCS features and system are described, including sensor displays and computer. An operational description is given of the distribution of information and controls on the instrument panel, the utilization of controls, the flight director, the fly-through steering, the monitoring of sensors and computer peripherals, and the power margin and flight envelope. C.D.

A89-23337#
AIRCRAFT MOTION SENSOR INTEGRITY FOR HELICOPTER AUTOMATIC FLIGHT CONTROL
WOLFGANG HASSENPFLUG (LITEF GmbH, Freiburg im Breisgau, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 17 p.

The paper considers the parallel and skewed axis configuration integrity levels to be achieved with a system architecture consisting of two strap down inertial reference units, one Doppler velocity sensor, one magnetometer, one radar altimeter, and an analytical TAS determination for the speed regime of a helicopter. It is shown that the utilization of strap-down technology enhances system integrity for flight safety critical parameters and provides the navigation accuracy required for modern combat and transport helicopters. K.K.

A89-23356#
DIGITAL MAP READER FOR HELICOPTER
J. CLOUE (Thomson-CSF, Paris, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 10 p.

Map requirements for helicopters are briefly reviewed with reference to the principal types of Army helipter missions (i.e., reconnaissance, anti-tank, support, and utility). Digital map technology is then examined, and the advantages of digital map readers are discussed. It is noted that the development of the digital map generator reduces the workload on helicopter crews, allowing them more time to concentrate on their mission. V.L.

A89-23378#
THE MODULARITY OF THE HEALTH AND USAGE MONITORING SYSTEM
P. D. BAKER (Smiths Industries Aerospace and Defence Systems, Ltd., London, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 18 p. refs

The Health and Usage Monitoring System, whose purpose is to enable the aircraft operator to provide safe and reliable means of transportation within defined operational limits, is described. Data can be accepted by the system from any type of sensor. These data are validated before compression and storage, for subsequent examination, or for immediate utilization in a variety of functions. The modular approach is considered as well as the modular system, the modular monitor, and life cycle costs. K.K.

A89-24851
CIVIL AVIONICS - THE FUTURE INTERNATIONAL SCENE; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, MAR. 17, 1988
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1988, 142 p. For individual items see A89-24852 to A89-24859.

The present conference discusses the operator's viewpoint in civil avionics design, the next-generation avionics employed by the A320 airliner, recent advancements in flying control systems, and the avionics system architecture employed by the Beechcraft Starship 1. Also discussed are the activities and determinations of the Special Committee on Future Air Navigation Systems, future developments in integrated avionics, the ARINC 629 data bus system, and next-generation engine controls. O.C.

A89-24852
SETTING THE SCENE - THE OPERATOR'S VIEWPOINT
D. H. FEATHERSTONE (Aeronautical Radio, Inc., Annapolis, MD) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 1-10.

After an evaluation of the ways in which technological advancements in electronics can be exploited for economic gain in the airline industry, attention is given to such emerging technologies as the Microwave Landing System, the Mode S upgrade of the Secondary Surveillance Radar System, and the Airborne Collision Avoidance System. The Airlines Electronic Engineering Committee anticipates that these systems will operate in parallel with existing ones for some time, allowing airlines to train with, and then transition to, the new systems as economics permit. O.C.

A89-24853
A320 - THE NEXT GENERATION AIRLINE AIRCRAFT
P. POTOCKI DE MONTALK (Airbus Industrie, Blagnac, France) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 11-28.

The A320, benefiting from A300/A310 design experience and exploiting the capabilities of electrically-signalled controls and propulsion, will achieve a substantial reduction in cockpit hardware with corresponding savings in weight and acquisition costs. Attention is presently given to the A320's optional Aircraft Integrated Data System and the Central Fault Data System (CFDS), which houses the interface between the aircraft's avionics system units and the multipurpose Control and Display Units. The CFDS is of 'federated' rather than 'centralized' type. O.C.

A89-24855
THE EQUIPMENT SCENE
J. L. WESTON (Smiths Industries Aerospace and Defence Systems Co., London, England) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 65-80.

A comprehensive evaluation is made of design imperatives in state-of-the-art flight control equipment, which increasingly exploits digital/intelligent and fly-by-wire technologies. The goals of these development efforts encompass, in addition to superior accuracy and response-time performance, greater system integration, higher reliability, lower weight, diminished power requirements, and lower costs. Attention is given to development and economic trends in computer RAMs, gate arrays, and memory densities, as well as to the design of active-matrix liquid-crystal displays and their matrix pixel configuration. Features of the software development cycle for flight control systems are also noted. O.C.

A89-24857
INTEGRATED AVIONICS - FUTURE DEVELOPMENTS
PETER L. SUTCLIFFE (Boeing Commercial Airplane Co., Seattle, WA) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 91-108.

The Integrated Avionics Computer System (IACS) concept's formulation has been prompted by the availability of new families of 32-bit, ultrahigh speed and fault-tolerant ICs, as well as the existence of Ada software possessing robust partitioning features. These elements point toward the development of IACS cabinets containing the central processing, data-interface, and power supply bases for a set of resilient functions, each of which will no longer individually require such capabilities. The benefits thus obtained take the form of substantial reductions in the weight, volume, and power requirements of the aggregate functions encompassed by IACS cabinets. O.C.

A89-24858
ARINC 629 DATA BUS SYSTEM
JOHN L. SHAW and PETER L. SUTCLIFFE (Boeing Commercial Airplane Co., Seattle, WA) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 109-129.

The ARINC 629 two-way/high-speed data bus system, which is approaching the final stages of certification as the new standard data bus for commercial aircraft, has been designated the 'Digital Autonomous Terminal Access Communications' system due to its operation's independence from the health-status of any other LRU connected to the bus. ARINC 629 will allow all aircraft avionics components to be accessed in order to conduct system operation, health-monitoring, failure reporting, and software-updating Approximately 1150 lbs of electrical wiring will be saved by the system, in the case of an aircraft of B757 size. O.C.

N89-15911*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE TRAFFIC-ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) IN THE GLASS COCKPIT
SHERYL L. CHAPPELL Dec. 1988 19 p Presented at the workshop on the Traffic-Alert and Collision Avoidance System (TCAS) implementation for Aircraft with Cathode Ray Tube (CRT) or Flat Panel Displays, Moffett Field, CA, 26-27 Jan. 1988
(NASA-TM-101036; A-88299; NAS 1.15:101036) Avail: NTIS HC A03/MF A01 CSCL 17G

This volume contains the contributions of the participants in the NASA Ames Research Center workshop on the traffic-alert and collision avoidance system (TCAS) implementation for aircraft with cathode ray tube (CRT) or flat panel displays. To take advantage of the display capability of the advanced-technology aircraft, NASA sponsored this workshop with the intent of bringing together industry personnel, pilots, and researchers so that pertinent issues in the area could be identified. During the 2-day workshop participants addressed a number of issues including: What is the optimum format for TCAS advisories. Where and how should maneuver advisories be presented to the crew. Should the maneuver advisories be presented on the primary flight display. Is it appropriate to have the autopilot perform the avoidance maneuver. Where and how should traffic information be presented to the crew. Should traffic information be combined with weather and navigation information. How much traffic should be shown and what ranges should be used. Contained in the document are the concepts and suggestions produced by the workshop participants. Author

N89-15912# Institute for Defense Analyses, Alexandria, VA.
THE EFFECT OF TECHNOLOGY ON THE SUPPORTABILITY AND COST OF AVIONICS EQUIPMENT Final Report, Jan. - Jul. 1988
DANIEL B. LEVINE, STANLEY A. HOROWITZ, and JOSEPH W. STAHL Aug. 1988 21 p
(Contract MDA903-84-C-0031)
(AD-A200450; AD-E501029; IDA-P-2140; IDA/HQ-88-33693)
Avail: NTIS HC A03/MF A01 CSCL 01C

This paper examines the question whether the advance from solid state to microminiaturized devices has made avionics equipment more costly and less supportable. It reports the results of an analysis that relates electronic technology and its maturation to the reliability, maintainability, and cost of some thirty items of avionics equipment. GRA

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A89-20949* General Motors Corp., Indianapolis, IN.
DEVELOPMENT OF AN ANALYTICAL MODEL TO ASSESS FUEL PROPERTY EFFECTS ON COMBUSTOR PERFORMANCE
R. D. SUTTON, D. L. TROTH, G. A. MILES (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and S. M. RIDDLEBAUGH (NASA, Lewis Research Center, Cleveland, OH) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 4, no. 3-4, 1987, p. 307-322. refs

A generalized first-order computer model has been developed in order to analytically evaluate the potential effect of alternative fuels' effects on gas turbine combustors. The model assesses the size, configuration, combustion reliability, and durability of the combustors required to meet performance and emission standards while operating on a broad range of fuels. Predictions predicated on combustor flow-field determinations by the model indicate that fuel chemistry, as defined by hydrogen content, exerts a significant influence on flame retardation, liner wall temperature, and smoke emission. O.C.

A89-20950* Yale Univ., New Haven, CT.
VAPOR DEPOSITION AND CONDENSATE FLOW ON COMBUSTION TURBINE BLADES - THEORETICAL MODEL TO PREDICT/UNDERSTAND SOME CORROSION RATE CONSEQUENCES OF MOLTEN ALKALI SULFATE DEPOSITION IN THE FIELD OR LABORATORY
DANIEL E. ROSNER and R. NAGARAJAN (Yale University, New Haven, CT) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 4, no. 3-4, 1987, p. 323-347. refs
(Contract NAG3-201; NAG3-590)

An analysis is undertaken of aerodynamically- and centrifugally-driven liquid condensate layers on nonisothermal combustion turbines' stator vanes and rotor blades. Attention is given to the quantitative consequences of one possible mechanism for the initiation of 'hot corrosion' in the underlying blade material through a 'fluxing' of the protective oxide coating by the molten salt of the Newtonian condensate film. Illustrative calculations are presented for the condensate streamline pattern and the distributions of the steady-state condensate layer thickness, together with the corresponding oxide dissolution rate, for a test turbine blade. O.C.

A89-21401
THE UNDUCTED FAN - WHY AND HOW? [LE TURBOREACTEUR A HELICES RAPIDES - POURQUOI ET COMMENT?]
J. CALMON (ONERA, Chatillon-sous-Bagneux, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 132, 1988, p. 3-15. In French.

The development and characteristics of the contrarotating unducted fan, designed to achieve a 25 percent lower specific fuel consumption than the second generation high-bypass turbofan, are discussed. The double-body gas generator employed has a global compression ratio at takeoff of 36 and uses a separate turbine stage for each of the two fan units. An unducted fan with a thrust at takeoff of 11,000 daN has been developed for a sustained Mach number of 0.80. The design consists of 11 blades for the first stage and 9 blades for the second stage. R.R.

A89-21555
PULSATIONS AND VIBRATIONS IN A TURBINE RESULTING FROM THE INTERACTION BETWEEN NOZZLE VANES AND ROTOR BLADES [PUL'SATSII I VIBRATSII V TURBINE, OBUSLOVLENNYE VZAIMODEISTVIEM LOPATOK SOPLOVOGO APPARATA I RABOCHEGO KOLESA]
A. N. ANTONOV, B. I. BOROVSKII, L. A. TOLSTIKOV, V. L. KHITRIK, and A. I. CHUCHEROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 22-25. In Russian.

Expressions are obtained for analyzing the relative amplitudes of pulsations and vibrations in a turbine which result from the interaction between nozzle vanes and rotor blades. To assess the validity of the model proposed here, a comparison is made between the model predictions and experimental data. The two sets of results agree to within 15 percent. V.L.

A89-21556
CHANGES IN THE CHARACTERISTICS OF GAS TURBINE HELICOPTER ENGINES WITH THE ACCRUED OPERATING TIME [IZMENENIE KHARAKTERISTIK VERTOLETNYKH GTD PO NARABOTKE]
A. I. BELOUSOV, IU. N. MAL'TSEV, and V. A. ZRELOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 26-29. In Russian.

The performance of gas turbine helicopter engines is investigated experimentally in an effort to establish a relationship between the throttle characteristic of an engine and the accrued operating time. Empirical expressions are obtained which relate changes in engine power to a derivative function describing the throttle characteristic; the region of a sharp decrease in engine power is determined. V.L.

A89-21564
EFFECT OF MERIDIONAL PROFILING IN A NOZZLE RING WITH A SMALL ANGLE OF FLOW DEFLECTION ON THE STAGE CHARACTERISTICS [VLIIANIE MERIDIONAL'NOGO PROFILIROVANIIA V SOPLOVOM APPARATE S MALYM UGLOM POVOROTA POTOKA NA KHARAKTERISTIKI STUPENI]
A. I. ARKHIPOV, M. K. MAKSUTOVA, and V. N. TARASOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 60-62. In Russian. refs

In earlier studies, meridional profiling has been proposed as an efficient method of improving the gasdynamic characteristics of nozzle rings with a small relative blade height. Here, results of comparative experimental studies of stages with meridional profiling are presented to show that, in the case of nozzle rings with a small angle of flow deflection, meridional profiling does not produce the desired effect. V.L.

A89-21571
A STUDY OF FLOW CHARACTERISTICS IN MODELS OF GAS TURBINE ENGINE LAVAL NOZZLES IN STATIONARY AND NONSTATIONARY REGIMES [ISSLEDOVANIE OSOBENNOSTEI TECHENIIA V MODELIAKH SOPEL LAVALIA GTD NA STATSIONARNYKH I NEUSTANOVIVSHIKHSIA REZHIMAKH]
IU. I. TSYBIZOV and V. V. ZAGVOZDKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 85-87. In Russian.

Test results are presented for Laval nozzle models representing the nozzles of gas turbine engines operating with low expansion ratios. It is shown, in particular, that the shape of the subsonic section and the rate of change of the operating conditions have a noticeable effect on flow characteristics, pulsations, structural vibrations, and noise level. The test procedure and the test equipment used are described. V.L.

A89-21573
OPTIMIZATION OF THE PARAMETERS OF MULTISTAGE AXIAL-FLOW COMPRESSORS [OPTIMIZATSIIA PARAMETROV OSEVYKH MNOGOSTUPENCHATYKH KOMPRESSOROV]
I. N. EGOROV and V. N. FOMIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 89, 90. In Russian.

A stochastic approach of the Monte Carlo type for the optimization of multistage axial-flow compressors is described. The approach involves statistical testing of a mathematical model of the compressor which allows for the characteristics of each blade crown at the mean radius. The compressor model is treated as a 'black box', which is subjected to a computer experiment. The advantage of the approach is that the computational effort in this case depends only slightly on the dimensionality of the problem. V.L.

A89-21574
DIRECT AND INVERSE POLYNOMIALS FOR COMPUTER-AIDED THERMAL ANALYSIS OF GAS TURBINE ENGINES [PRIAMYE I OBRATNYE POLINOMY DLIA TEPLOVYKH RASCHETOV NA EVM TURBOMASHIN GTD]
V. I. LOKAI, M. U. ZAKIROV, and R. S. AGACHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 91-93. In Russian.

An approach to the thermal analysis of aviation gas turbine engines is proposed which uses direct and inverse polynomials for thermodynamic functions based on data on the specific heat of air and 'pure' combustion products of a standard hydrocarbon fuel (85.5 pct C + 14.5 pct H). Details of the approach and a method for reducing the number of polynomials required for the analysis are discussed. V.L.

A89-22009#
EXPERIMENTAL STUDY OF DISTRIBUTIONS AT EXIT OF TURBOJET AFTERBURNER USING GAS ANALYSIS SYSTEM
YIXIANG HAN and HAO LIU (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 295-298. In Chinese, with abstract in English.

A new gas analysis system was established to measure the distributions of the fuel air ratio, the combustion efficiency and the exhaust gas temperature at the afterburner exit in engine test bench. A number of technical problems, such as simultaneously sampling, automatically collecting and analysis, were overcome in this study. It has been proved that the repeatability, reliability and accuracy of the measurements are quite good. This method is effective and becomes a very important tool, providing a direction to improve the performance of afterburner. Author

A89-22291*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONTINGENCY POWER FOR SMALL TURBOSHAFT ENGINES
THOMAS J. BIESIADNY, BRETT BERGER (NASA, Lewis Research Center, Cleveland, OH), GARY A. KLANN, and DAVID A. CLARK (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 103-108. Previously cited in issue 20, p. 3156, Accession no. A87-45289. refs

A89-22292#
ACOUSTIC CHARACTERIZATION RELEVANT TO GAS TURBINE AUGMENTORS
S. SIVASEGARAM, J. H. WHITELAW (Imperial College of Science and Technology, London, England), and B. E. THOMPSON (Scientific Research Associates, Inc., Glastonbury, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 109-115. refs
(Contract N00140-87-C-9684)

The influence of geometric and flow variables on combustion instability in confined flames stabilized behind a disk is examined. Flammability and stability limits are established as a function of upstream and downstream lengths for ducts with and without exit nozzles. The upstream flow conditions were either uniform premixed flow or a premixed main flow with annular bypass airflow. Combustion was smooth for unconstricted downstream ducts shorter than five diameters, and ducts with nozzle exits shorter than one diameter. Constriction of the exit favored rough combustion but with lower amplitude oscillations. With moderate downstream lengths, oscillations were associated with the longitudinal quarter-wave frequency of the upstream duct between 150 Hz and 200 Hz. Rough combustion was not observed with short upstream ducts that have quarter-wave frequencies much higher than the maximum value of the dominant frequency. In longer downstream ducts with nozzles, the acoustic frequency gave way to lower frequencies not associated with any known acoustic frequency of the combustor. The geometry with bypass flow was more prone to rough combustion and to transition to low-frequency oscillations at shorter downstream lengths. Author

A89-22926
AIRCRAFT ENGINES. II
MARTIN G. SMITH, JR. (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) Exxon Air World, vol. 40, no. 3, 1988, p. 20-22.

An account is given of the design features and prospective

performance gains of ultrahigh bypass subsonic propulsion configurations and various candidate supersonic commercial aircraft powerplants. The supersonic types, whose enhanced thermodynamic cycle efficiency is considered critical to the economic viability of a second-generation SST, are the variable-cycle engine, the variable stream control engine, the turbine-bypass engine, and the supersonic-throughflow fan. Also noted is the 'turboramjet' concept, which will be applicable to hypersonic aircraft whose airframe structure materials can withstand the severe aerothermodynamic conditions of this flight regime. O.C.

A89-22927* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AIRCRAFT ENGINES. III
DANIEL C. MIKKELSON (NASA, Lewis Research Center, Cleveland, OH) and GREGORY M. RECK (NASA, Office of Aeronautics and Space Technology, Washington, DC) Exxon Air World, vol. 40, no. 3, 1988, p. 22-26.

Prospective powerplant configuration advancements for tilt-rotor subsonic flight, supersonic commercial flight, and hypersonic flight are speculated upon, with a view to possibilities for the exploitation of novel materials and of such advanced fuels as liquid methane and hydrogen. Attention is given to the foldable tilt-rotor concept, which employs a hydraulic torque converter to engage the fan stage of the high-bypass turbofan engine used in forward flight after the tilt-rotor blades have been stowed, and several advanced cycles and turbomechanical configurations for cruise in the high supersonic regime and beyond, through the hypersonic regime, and into orbital velocity. O.C.

A89-23148
A COMBAT ENGINE FOR EUROPE - EJ200
J. D. WRAGG (Rolls-Royce, PLC, Bristol, England) Aerospace (UK) (ISSN 0305-0831), vol. 16, Jan. 1989, p. 8-15.

The development history, current status, design features and prospective performance of the European Fighter Aircraft's EJ200 low-bypass turbofan engine are presented. The EJ200 design configuration, materials, manufacturing methods, and control systems are substantially derived from those of the XG40 technology-demonstrator engine program, which began in 1983. The EJ200 is in the 10:1 thrust:weight class, generates 90 kN on afterburner, achieves an overall pressure ratio of more than 25:1 on the basis of two spools of three low-pressure (fan) stages and five high-pressure stages, respectively, and possesses a fan pressure ratio of 4.2:1. O.C.

A89-23149
STAGES AND OBJECTIVES OF TURBOJET ENGINE DEVELOPMENT
HANS GEORG MUENZBERG (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) (European Pioneer's Day, 12th, London, England, Sept. 12, 1988) Aerospace (UK) (ISSN 0305-0831), vol. 16, Jan. 1989, p. 18-27. refs

The present account of the methodology of gas turbine engine development gives attention to the primary aircraft propulsion system performance factors of low fuel consumption, low mass, and high thrust/unit frontal area; a high thrust/unit frontal area value can only be achieved if the engine is as slender as possible and each component is designed for maximum possible capacity. The developmental emphases of future high-supersonic and hypersonic powerplants in which a great degree of inlet/engine/exhaust system integration is required are addressed. O.C.

A89-23182*# Ohio State Univ., Columbus.
EXPERIMENTAL STUDY OF ISOTHERMAL SWIRLING FLOWS IN A DUMP COMBUSTOR
M. SAMIMY (Ohio State University, Columbus) and C. A. LANGENFELD AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1442-1449. refs
(Contract F49620-85-C-0013; NAG3-764)

Detailed mean and turbulence data were obtained in a dump combustor with and without swirling inlet flow. A two-component LDV was used, and large samples were collected to resolve the second- and third-order correlations of velocity fluctuations with good accuracy. Large-amplitude well-organized oscillations were observed in the swirling flows and discussed. The swirling flows with and without vortex breakdown exhibited significantly different mean flow and turbulence field behavior. Author

A89-23187#
NUMERICAL INTEGRATION OF THE BLADE-TO-BLADE SURFACE EULER EQUATIONS IN VIBRATING CASCADES
G. A. GEROLYMOS (SNECMA, Moissy Cramayel, France) AIAA Journal (ISSN 0001-1452), vol. 26, Dec. 1988, p. 1483-1492. refs

The unsteady aerodynamics of fluttering cascades is a demanding problem in the analysis of modern compressors. An algorithm has been developed for numerically integrating the Euler equations in blade-to-blade surface formulation. The method simulates all the interblade channels of an annular cascade. The equations are discretized in a grid that moves in order to follow the vibration of the blades. The equations are integrated using the explicit MacCormack scheme in finite-difference formulation. Mistuned vibration as well as standing-, traveling-, or influence-wave modes may be readily simulated. Also, two other faster methods have been developed, simulating traveling and influence waves, respectively. A number of numerical results show the aptitude of the method to simulate both started and unstarted supersonic flow in vibrating cascades. A first comparison with available wind-tunnel data corroborates the validity of this approach to predict supersonic flutter of fans and compressors. Author

A89-23807
MTU PROPFAN PROJECT CRISP FOR PERFORMANCE ANALYSIS IN DFVLR WIND TUNNELS [MTU-PROPFAN-PROJEKT CRISP ZUM LEISTUNGSNACHWEIS IN DEN WINDKANAELEN DER DFVLR]
BURKHARD BINDER and RUDOLF WULF (DFVLR, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 2-4. In German.

The CRISP (Counter Rotating Integrated Shrouded Propfan) project uses the DFVLR wind tunnel in Goettingen, along with a national performance analysis model, to develop a new engine concept for commercial air traffic. The flow mechanics and wind tunnel structure involved in this development are described here. The project phases are identified and described. C.D.

A89-23816
PREPARATION OF EXPERIMENTAL STUDIES OF CASCADE VIBRATIONS [VORBEREITUNG EXPERIMENTELLER UNTERSUCHUNGEN VON SCHAUFELGITTERSCHWINGUNGEN]
WERNER SACHS (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 43-46. In German.

Preparations being made for experimental aeroelastic studies of unsteady effects on cascades are discussed. A new wind tunnel for the study of vibrating cascades is described. A general idea is given of the data processing involved in the experiment. C.D.

A89-23871
THE RELATION BETWEEN LOSSES AND ENTRY-FLOW CONDITIONS IN SHORT DUMP DIFFUSERS FOR COMBUSTORS
A. KLEIN Aeronautical Journal (ISSN 0001-9240), vol. 92, Dec. 1988, p. 390-396. refs

An experimental correlation is presented between the losses and the inlet flow conditions in short dump diffusers for turbojet combustors. Cascades of compressor blades upstream of the diffuser were used to make the flow field at inlet similar to that in a real jet engine. The flow field was altered in two ways - by varying the distance between the cascades and the diffuser inlet plane and by changing the blade aspect ratio. The measurements show clearly that distortions in the radial direction affect the losses

to a much larger extent than non-uniformities in the circumferential direction. In consequence, the performance can be correlated to a satisfactory degree of accuracy simply by using the radial blockage factor at inlet. Author

A89-23872
FROM SIR FRANK WHITTLE TO THE YEAR 2000 - WHAT IS NEW IN PROPULSION?
J. CALMON (Academie Nationale de l'Air et de l'Espace, Toulouse, France) Aeronautical Journal (ISSN 0001-9240), vol. 92, Dec. 1988, p. 397-408.

A development history and prospective-developments projection is presented for both subsonic/high-efficiency and supersonic/high-performance aircraft gas turbine engines. The mastering of compressor aerodynamics is noted to be the basis of current success with propulsion systems of both sub- and supersonic types; much effort has recently been expended on the refinement of propeller and fan aerodynamics, and it has been suggested that coaxial contrarotating turbine drives for unducted fans will constitute an important performance improvement over conventional gearbox-driven rotors. Substantial advancements have also occurred in engine hot section component materials and active cooling techniques. Attention is given to emerging supersonic and hypersonic propulsion turbomachine configurations. O.C.

A89-24859
FUTURE ENGINE CONTROLS
C. D. JACK (Rolls-Royce, PLC, London, England) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 130-139.

The design constraints encountered by the developers of full-authority digital engine control (FADEC) systems are discussed, with a view to emerging technologies that may prove useful in the implementation of such systems. Attention is given to a FADEC system configuration in which heavy electrical cabling is replaced by optical fiber connections for all transducers and actuators. In addition to weight savings, this will result in improved reliability and maintainability, as well as immunity to lightning-induced EMI and a cost that is merely half that of current, comparably capable FADEC systems. O.C.

N89-15112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ANALYSIS OF AN UNSWEPT PROPFAN BLADE WITH A SEMIEMPIRICAL DYNAMIC STALL MODEL
T. S. R. REDDY (Toledo Univ., OH.) and K. R. V. KAZA Washington, DC Jan. 1989 23 p
(NASA-TM-4083; E-4196; NAS 1.15:4083) Avail: NTIS HC A03/MF A01 CSCL 21E

The time history response of a propfan wind tunnel model with dynamic stall is studied analytically. The response obtained from the analysis is compared with available experimental data. The governing equations of motion are formulated in terms of blade normal modes which are calculated using the COSMIC-NASTRAN computer code. The response analysis considered the blade plunging and pitching motions. The lift, drag and moment coefficients for angles of attack below the static stall angle are obtained from a quasi-steady theory. For angles above static stall angles, a semiempirical dynamic stall model based on a correction to angle of attack is used to obtain lift, drag and moment coefficients. Using these coefficients, the aerodynamic forces are calculated at a selected number of strips, and integrated to obtain the total generalized forces. The combined momentum-blade element theory is used to calculate the induced velocity. The semiempirical stall model predicted a limit cycle oscillation near the setting angle at which large vibratory stresses were observed in an experiment. The predicted mode and frequency of oscillation also agreed with those measured in the experiment near the setting angle. Author

N89-15913*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA ADVANCED PROPELLER RESEARCH
JOHN F. GROENEWEG and LAWRENCE J. BOBER 30 Sep. 1988 34 p Presented at the Advanced Propellers and Their Installation on Aircraft, Cranfield, England, 26-27 Sep. 1988; sponsored in part by Royal Aeronautical Society
(NASA-TM-101361; E-4393; NAS 1.15:101361) Avail: NTIS HC A03/MF A01 CSCL 21E

Acoustic and aerodynamic research at NASA Lewis Research Center on advanced propellers is reviewed including analytical and experimental results on both single and counterrotation. Computational tools used to calculate the detailed flow and acoustic fields are described along with wind tunnel tests to obtain data for code verification. Results from two kinds of experiments are reviewed: (1) performance and near field noise at cruise conditions as measured in the NASA Lewis 8- by 6-foot Wind Tunnel; and (2) far field noise and performance for takeoff/approach conditions as measured in the NASA Lewis 9- by 15-foot Anechoic Wind Tunnel. Detailed measurements of steady blade surface pressures are described along with vortex flow phenomena at off-design conditions. Near field noise at cruise is shown to level out or decrease as tip relative Mach number is increased beyond 1.15. Counterrotation interaction noise is shown to be a dominant source at takeoff but a secondary source at cruise. Effects of unequal rotor diameters and rotor-to-rotor spacing on interaction noise are also illustrated. Comparisons of wind tunnel acoustic measurements to flight results are made. Finally, some future directions in advanced propeller research such as swirl recovery vanes, higher sweep, forward sweep, and ducted propellers are discussed.
Author

N89-15919# Cincinnati Univ., OH. Dept. of Aerospace and Engineering Mechanics.
PART 5 AND 6: TURBOMACHINERY PERFORMANCE DETERIORATION AND RETENTION
WIDEN TABAKOFF and AWATEF A. HAMED *In* Von Karman Institute for Fluid Dynamics, Particulate Flows and Blade Erosion 49 p 1988
Avail: NTIS HC A24/MF A01

Analysis of aircraft engine disassembly inspections showed that the causes of deterioration fall into three basic categories: deposition, erosion, and rubbing wear. Dirt deposition, mainly on the compressor blading causes loss of flow capacity and efficiency. The designer cannot prevent the dirt in the atmosphere, but can improve the oil seals to prevent oil escaping onto airfoils where it forms a sticky surface attracting particles. Erosion in high bypass engine core compressors is reduced by the centrifugal effect of the preceding fan, tending to deflect heavy particles through the fan duct. This can be achieved by increasing spacing between the fan exit and core inlet. Erosion also affects the attrition links of the casings which form the blade tip seals. Rubbing contact can occur on many of the seals between static and rotating parts and accounts for part of the deterioration. ESA

N89-15923# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Applied Mechanics.
PART 4: BLADE EROSION PREDICTION
AWATEF A. HAMED *In* Von Karman Institute for Fluid Dynamics, Particulate Flows and Blade Erosion 51 p 1988
Avail: NTIS HC A24/MF A01

The procedure for predicting turbomachine blade erosion, based on the particle trajectory calculations output, and the correlation of the blade material erosion by the ingested particles is described. The computed blade erosion pattern and intensity are presented in the case of axial flow turbines and compressors, in radial inflow turbines, in centrifugal compressors, and in the swirling vanes of an inlet separator. The results are used to describe the general characteristics of blade erosion in each case and to discuss the factors that influence the various blade erosion parameters. ESA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A89-20957#
ON THE CONTROL OF AUTO-ROTATIONAL CHARACTERISTICS OF A LIGHT TRAINER AIRCRAFT FUSELAGE
B. N. PAMADI (Indian Institute of Technology, Bombay, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Feb. 1988, p. 55-61.

Single-degree-of-freedom free-to-roll tests in a low-speed open jet wind tunnel are carried out on a scaled model of the fuselage of a single-piston-engine light trainer airfcraft for alpha = 30 to 90 deg. Strakes of three different heights were installed on the bottom side at various locations to explore the feasibility of controlling its autorotational behavior. It is believed that the results of this study will be useful in finding a solution to the problem of oscillatory spin of the corresponding full-scale model. K.K.

A89-21554
OPTIMIZATION OF A COMPLEX BAROINERTIAL COMPUTER OF AIRCRAFT'S VERTICAL VELOCITY AND FLIGHT HEIGHT [OPTIMIZATSIIA KOMPLEKSNOGO BAROINERTSIAL'NOGO VYCHISLITELIA VERTIKAL'NOI SKOROSTII I VYSOTY POLETA LA]
V. P. KHAR'KOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 18-22. In Russian. refs

The problem of the synthesis of an optimal adaptive algorithm for the complex processing of signals from static pressure and stagnation flow temperature transducers and from the vertical accelerometer is analyzed by using nonlinear filtering methods. The adaptive properties of the algorithm are largely due to the incorporation into the state vector of a system for estimating parameters characterizing the static pressure tract and transducers. The efficiency of the algorithm proposed here is verified through a numerical simulation. V.L.

A89-22504#
SHORT-RANGE NONLINEAR FEEDBACK STRATEGIES FOR AIRCRAFT PURSUIT-EVASION
P. K. A. MENON (Georgia Institute of Technology, Atlanta) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 27-32. refs

Prelinearizing transformations are combined with the linear quadratic pursuit-evasion game results to synthesize explcit nonlinear feedback strategies for aircraft pursuit-evasion in the endgame. Three-dimensional point-mass models for aircraft are employed in this work. Numerical results are given for two different engagement scenarios. Future applications include the derivation of collision avoidance strategies for aircraft, aircraft rendezvous, and guidance for coordinated maneuvering with other aircraft. Author

A89-22506#
COMBINING EXPERT SYSTEM AND ANALYTICAL REDUNDANCY CONCEPTS FOR FAULT-TOLERANT FLIGHT CONTROL
ROBERT F. STENGEL (Princeton University, NJ) and DAVID A. HANDELMAN (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 375-384) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 39-45. Previously cited in issue 23, p. 3409, Accession no. A86-47442. refs
(Contract DAAG29-84-K-0048)

A89-22507*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EVALUATION OF A COMMAND MONITORING CONCEPT FOR A V/STOL RESEARCH AIRCRAFT
J. A. SCHROEDER, E. MORALEZ, and V. K. MERRICK (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 46-53. Previously cited in issue 22, p. 3542, Accession no. A87-50536. refs

A89-22509*# Princeton Univ., NJ.
STABILITY BOUNDARIES FOR AIRCRAFT WITH UNSTABLE LATERAL-DIRECTIONAL DYNAMICS AND CONTROL SATURATION
PRAKASH C. SHRIVASTAVA and ROBERT F. STENGEL (Princeton University, NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 62-70. refs
(Contract NGL-31-001-252)

Aircraft that do not possess inherent (aerodynamic) stability must rely on closed-loop control systems for stable operation. Because there are limits on the deflections of an aircraft's control surfaces, the region of stable operation also is bounded. These boundaries are investigated for a lateral-directional example in which vertical fin size is inadequate to provide directional stability and where aileron and rudder deflections are subject to saturation. Fourth-order models are used in this study, with flight control logic based on minimum-control-energy linear-quadratic-regulatory theory. It is found that the stability boundaries can be described by unstable limit cycles surrounding stable equilibrium points. Variations in regions of stability with gain levels and command inputs are illustrated. Current results suggest guidelines for permissible limits on the open-loop instability of an aircraft's lateral-directional modes. Author

A89-22516#
PITCH POINTING FLIGHT CONTROL SYSTEM DESIGN IN THE FREQUENCY DOMAIN
FANG-BO YEH and THONG-SHING HWANG (National Cheng Kung University, Tainan, Republic of China) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 116-119.

The frequency domain design proposed for a multivariable aircraft control system decouples the multivariable system by means of an H(inf)-optimization technique. A stable minimum-phase weighting function is used to meet the desired damping ratio, and the rise-time is constructed. Using this optimization technique, the problem is treated exactly as the scalar problem in pitch-pointing control design; a diagonal closed-loop transfer function matrix of the multivariable design is obtained. O.C.

A89-22872#
FLIGHT TEST AND DATA ANALYSIS TECHNIQUES FOR HELICOPTER PARAMETER ESTIMATION
D. E. SATTLER (Carleton University, Ottawa, Canada) and R. D. KOBIERSKI (CASI, Flight Test Symposium, Ottawa, Canada, Mar. 24, 25, 1988) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Dec. 1988, p. 213-223. Research supported by DND. refs

Intended specifically to provide insight into flight test and data analysis techniques for helicopter parameter estimation, this paper commences with a brief review of aircraft parameter estimation. The equations of motion for an aircraft are then presented in a form appropriate for use with helicopter parameter estimation. A traditional method for helicopter parameter estimation is presented, whereby: control derivatives and associated time delays are obtained from step input data; static stability derivatives are obtained from trim data; and dynamic stability derivatives are obtained from fixed-frequency excitation. The attractive features of this method are found to be the simplicity of the concept and a concurrent better understanding of the processes involved. Also presented is a second, more advanced method which employs a modified maximum likelihood estimator to explore the methodology

of pilot interactively generated manual control during parameter estimation data generation. This method is shown to provide significantly improved confidence levels associated with estimation of all stability and control derivatives. Experience gained in the use of parameter estimation techniques during this research program indicates that helicopter parameter estimation has now matured to a level suitable for engineering applications. Author

A89-23301#
NUMERICAL SIMULATIONS OF DYNAMIC RESPONSE OF FIXED AND ROTARY WING AIRCRAFT TO A LARGE AIRPLANE WAKE
SHIGERU SAITO (National Aerospace Laboratory, Chofu, Japan), AKIRA AZUMA, YOSHINORI OKUNO, and TOMOHIKO HASEGAWA (Tokyo, University, Japan) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 36 p. refs

The dynamics of fixed and rotary wing aircraft penetrating a pair of vortices trailing a large aircraft is studied through numerical simulations. The aerodynamic forces acting on the main or rotary wing in six degrees of freedom are calculated using the local circulation method (Azuma et al., 1983) for the fixed wing and local momentum theory (Azuma and Kawachi, 1979) for the rotary wing. Time histories of the dynamic behavior of the aircraft are presented for several parameters, including the distance separating the two aircraft, mass and wing span or rotor radius, and flight path angle with respect to the tip vorticies of the preceding aircraft. It is found that the dynamic response of the fixed wing aircraft is much more severe than that of the helicopter. R.B.

A89-23304#
EFFECTS OF DIFFERENCE IN INDUCED VELOCITY DISTRIBUTION ON THE HELICOPTER MOTION
YOSHINORI OKUNO, AKIRA AZUMA, and KEIJI KAWACHI (Tokyo, University, Japan) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 23 p. refs

The change in the induced velocity distribution of a helicopter rotor operating in unsteady conditions is calculated using the local momentum theory (Azuma and Kawachi, 1976). The allowable range of application of the simple momentum theory (Azuma et al., 1986) is determined through a comparison with the local momentum theory. It is found that there is no difference in the results from the two theories for helicopter motion at high speeds. For helicopter motion at low flight speeds and for the blade deflections in high or low speeds, discrepancies are found in the results of the two theories. It is suggested that these discrepancies are due to a difference in the induced velocity distribution. R.B.

A89-23305*# Indian Inst. of Science, Bangalore.
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF STALL EFFECTS ON FLAP-LAG STABILITY IN FORWARD FLIGHT
J. NAGABHUSHANAM (Indian Institute of Science, Bangalore, India), GOPAL H. GAONKAR (Florida Atlantic University, Boca Raton), and MICHAEL J. MCNULTY (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 28 p. Research sponsored by the U.S. Army. refs
(Contract NCC2-361)

Experiments have been performed with a 1.62 m diameter hingeless rotor in a wind tunnel to investigate flap-lag stability of isolated rotors in forward flight. The three-bladed rotor model closely approaches the simple theoretical concept of a hingeless rotor as a set of rigid, articulated flap-lag blades with offset and spring restrained flap and lag hinges. Lag regressing mode stability data was obtained for advance ratios as high as 0.55 for various combinations of collective pitch and shaft angle. The prediction includes quasi-steady stall effects on rotor trim and Floquet stability analyses. Correlation between data and prediction is presented and is compared with that of an earlier study based on a linear theory without stall effects. While the results with stall effects show marked differences from the linear theory results, the stall theory still falls short of adequate agreement with the experimental data. Author

A89-23318#
HELICOPTER MANOEUVRABILITY TESTING IN PRACTICE
D. J. PRICE (Empire Test Pilots School, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 11 p.

The problem of providing necessary information to pilots as helicopters become more agile and structurally robust is addressed. The main issue is the utilization of the aircraft's full capacity. Consideration is given to tracking tasks, repeatable tasks, and the pilots' points of view. K.K.

A89-23326#
SIMULATION TESTS OF THE PILOT-HELICOPTER SYSTEM IN OVEREXTREME CONDITIONS
K. SZUMANSKI (Instytut Lotnictwa, Warsaw, Poland) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 22 p. refs

This paper describes investigations in the area of complex pilot-controlled helicopter dynamic systems under extreme conditions as indicated by the structural limits of the helicopter parts and assemblies. Helicopter loading and handling technique under these conditions are evaluated using a model of handling representation of helicopter flight. The situations addressed include power plant failure, helicopter turnover during takeoff and landing on sloping terrain, and limit maneuvers during low flying or hedgehopping. C.D.

A89-23360#
CONSIDERATION OF TRENDS IN STABILITY AND CONTROL DERIVATIVES FROM HELICOPTER SYSTEM IDENTIFICATION
C. G. BLACK (Glasgow, University, Scotland) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 27 p. Research supported by the Ministry of Defence Procurement Executive. refs

Methods for validating a complex nonlinear model of helicopter dynamics against measured flight data are considered. It is shown that a frequency-domain output-error estimation technique is a feasible and practical approach to the successful estimation of a rigid-body model which excludes rotor degrees of freedom. Problems arising in the identification of lateral stability derivatives, which are associated with strong correlations between some of the response variables in the 'Dutch-roll' type mode, are solved using rank-deficient versions of the information matrix. K.K.

A89-23361#
AN INVESTIGATION OF THE STABILITY OF FLIGHT PATH CONSTRAINED HELICOPTER MANOEUVRES BY INVERSE SIMULATION
D. G. THOMSON and R. BRADLEY (Glasgow, University, Scotland) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 16 p. Research supported by the Ministry of Defence. refs

A method has been developed which solves directly the inverse problem for helicopters flying well defined maneuvers associated with concealment, obstacle avoidance, and weapons delivery. The inverse method and a computer package incorporating it are briefly described, and some potential stability problems associated with constrained flight are examined. A technique is presented which makes it possible to predict such instabilities. V.L.

A89-23363#
THE IDENTIFICATION OF REDUCED ORDER MODELS OF HELICOPTER BEHAVIOUR FOR HANDLING QUALITIES STUDIES
S. S. HOUSTON and R. I. HORTON (Royal Aircraft Establishment, Flight Systems Dept., Bedford, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 27 p. refs

The applicability of the equivalent systems approach for characterizing the fundamentally complex behavior of conventional

single main and tail rotor helicopters is demonstrated. It is suggested that phase slope-bandwidth criteria may be inappropriate for characterizing the small-amplitude tracking task handling qualities of helicopters. However, evidence suggests that delay-bandwidth criteria are appropriate. K.K.

A89-23364#
H-INFINITY DESIGN AND THE IMPROVEMENT OF HELICOPTER HANDLING QUALITIES
ANDREW YUE, IAN POSTLETHWAITE (Oxford University, England), and GARETH PADFIELD (Royal Aircraft Establishment, Flight Research Div., Bedford, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 22 p. Research supported by SERC. refs

This paper presents the results of a study into the use of H-infinity optimization for the design of feedback control laws for improving the handling qualities of a combat helicopter. Control laws are designed for precise control of pitch and roll attitude, yaw rate and heave velocity for a combat helicopter in hover. To meet both the performance and robustness requirements of the controller, a two-degree of freedom structure is adopted, where the feedback compensator is designed to have desirable robustness properties (e.g., against model uncertainty and disturbances) and the pre-compensator is designed to achieve the performance objectives of tracking accuracy, speed of response, etc. A complete separation of command response and feedback properties can be achieved with this structure. Author

A89-23365#
HELICOPTER AGILITY IN LOW SPEED MANOEUVRES
M. T. CHARLTON, G. D. PADFIELD, and R. I. HORTON (Royal Aircraft Establishment, Flight Research Div., Bedford, England) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 27 p. refs

Flight trials conducted to explore the factors influencing helicopter agility in low-speed maneuvers are described. Results are presented for two stylized NOE maneuvers: the sidestep and quickhop, flown by two subject pilots in the RAE research Puma and Lynx. The aircraft were operated at relatively high levels of hover thrust margin to permit corresponding high values of initial translational acceleration. The goal was to determine the constraints on the use of full aircraft performance. Pilot ratings for handling qualities and workload were found to deteriorate from marginal Level 1, through Level 2 to Level 3 as the initial attitudes increase from 10-30 deg. It is concluded that a wide and clear field of view is required to maintain accurate flight path control close to the ground and that a carefree power demand control is highly desirable and would significantly reduce the workload. K.K.

A89-23381#
RECENT TILT ROTOR FLIGHT CONTROL LAW INNOVATIONS
DWAYNE F. KIMBALL (Bell Helicopter Textron, Inc., Fort Worth, TX) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p. refs

This paper describes three flight control law functions developed for a tilt rotor for V-22. The first of these was designed to quicken thrust response to power lever inputs by varying prop-rotor rpm though a governor feed-forward circuit; the second enables the power lever to directly control an aerodynamic brake formed by the aircraft's flaperon control surfaces; and the third protects against a drive system overtorque and reduces the thrust-axis workload in all flight modes. The improvements of the handling qualities of the aircraft resulting from each of these control-law functions, as determined by the analysis and flight simulation, are discussed. Design diagrams and block diagrams are presented. I.S.

A89-23977#
AUTOMATIC ROBUST LANDING CONTROL SYSTEM DESIGN FOR ENTE PLANE USING EQUIVALENT NONLINEAR ELIMINATION METHOD
SHOKICHI KANNO (Ichinoseki National College of Technology, Japan) and TATSUO CHUBACHI (Iwate University, Morioka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, Nov. 1988, p. 134-145. refs

An automatic robust landing control system for a canard-configuration aircraft is discussed, taking the nonlinearity of aircraft dynamics into consideration. The system uses the equivalent nonlinear elimination method and the theory of nonlinear perfect servo. It is suggested that the benefits of the system are simple computations, a small control flight path error, and the fact that the system does not need a precise control derivative value. Simulations for a canard-configuration aircraft gave good results. R.B.

A89-24310#
SUPERSONIC FLUTTER OF AEROELASTICALLY TAILORED OBLIQUE WINGS
TERRENCE A. WEISSHAAR and JONATHAN D. BOHLMANN (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 55-65) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 75-83. Previously cited in issue 14, p. 2109, Accession no. A87-33661. refs
(Contract N62269-85-C-0268)

A89-24311*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
INTEGRATED AEROSERVOELASTIC ANALYSIS CAPABILITY WITH X-29A COMPARISONS
K. K. GUPTA, M. J. BRENNER, and L. S. VOELKER (NASA, Flight Research Center, Edwards, CA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 636-647) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 84-90. Previously cited in issue 14, p. 2110, Accession no. A87-33716. refs

A89-24487
THE NEW COMPLEMENT FOR AIR AND SPACECRAFT - A MAN/A COMPUTER
M. J. PELEGRIN (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) and B. ZIEGLER (Airbus-Industrie, Blagnac, France) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 103-115.

The current status of fly-by-wire technology for commercial aircraft is surveyed, with an emphasis on the A320 man-machine interface. Topics addressed include ergonomics and screen use in electronic panel instruments; fly-by-wire aircraft with computers in cascade; global, hardware, and software reliability issues; distributed processing; flight-envelope and wind-shear protection; stability augmentation; and active flutter suppression. Consideration is given to variable-camber wing control, autonomous navigation, category III automatic landing, maintenance aids, and future developments. Diagrams, graphs, and drawings are provided. T.K.

A89-24488
DESIGN AND FLIGHT TESTING OF A MODEL FOLLOWING CONTROL SYSTEM FOR HELICOPTERS
G. BOUWER (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 117-123.

The design concept and performance of a prototype model-following control system for a BO-105 helicopter are discussed and illustrated with diagrams, drawings, graphs, photographs, and tables of numerical data. The derivation of the mathematical model is outlined, and the numerical implementation is briefly explained, The flight-test results demonstrate the

capabilities of the system in dealing with helicopter nonlinearities and couplings; a high degree of disturbance rejection is obtained. T.K.

A89-24489
AN OPEN-LOOP CONTROL SYSTEM FOR A STATE SPACE FLIGHT CONTROLLER
A. REDEKER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 125-131.

If a strong nonlinear multiloop plant like longitudinal aircraft motion is controlled by a linear algorithm, results are only satisfactory within a rather small operating range. A combination of a nonlinear forward-feeding model and an open-loop adaption of the feedback gains enables an operation over the whole operating range. The forward-feeding model is represented by a quasi-stationary inverse of the mathematical model of the plant. A flight controller with a structure like this has been designed and flight-tested. It was demonstrated that the whole flight envelope, including flare during an automatic landing, can be performed by the same algorithm. Author

A89-24490
IDENTIFICATION OF THE LONGITUDINAL MOTION OF A DORNIER DO 28 AIRPLANE
K.-O. PROSKAWETZ (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 130-138. refs

The current status of efforts to fully identify a Do 28 twin-engine propeller aircraft model at the Technische Universitaet Braunschweig is surveyed. Topics discussed include the measurement and data-acquisition system, problems in the analysis of pulse-code-modulated data, the general maximum-likelihood formulation, and data-compatibility checks. Particular attention is given to the nonlinear model developed for longitudinal motion identification. Diagrams, drawings, graphs, and tables of numerical data are provided. T.K.

A89-24491
A NEW MODEL REFERENCE ADAPTIVE AIRCRAFT CONTROLLER
J. CHANDRASEKHAR (Indian Institute of Technology, Bombay, India) and M. P. R. V. RAO (Ulster, University, Belfast, Northern Ireland) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 139-144. refs

The theoretical basis and numerical implementation of a model-reference adaptive aircraft pitch controller based on the Liapunov formulation of Narendra and Valavani (1978) and the modified adaptive laws of Chandrasekhar and Vittal Rao (1985) are described. The basic equations of aircraft longitudinal motion are presented, and the derivation of the model (using adaptive laws of form proportional + integral + double integral) is given in detail. Results from numerical simulations of six flight conditions are presented in tables and graphs and briefly characterized; satisfactory performance is demonstrated. T.K.

A89-24492
AN AUTOMATIC FLIGHT CONTROL SYSTEM FOR VTOL AIRCRAFT SUPPORTED BY DUCTED FANS
S. NIWA (Nagoya University, Japan) and I. SUGIURA (Chubu University, Kasugai, Japan) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 145-150. refs

This paper presents the design of an AFCS for VTOL research aircraft supported by four ducted fans. Ducted-fan VTOL aircrafts have not been utilized due to problems such as stability and control, fuel efficiency, etc. A research model of the ducted-fan VTOL has been developed which weighs 50 kg and is powered by a 10-hp electric motor. An AFCS is designed to control its attitude and altitude. One-axis attitude-control experiments on the test stand, suspended three-axis attitude-control tests, and control tests using a perpendicular pole (which enables 4-DOF motion) were performed. Automatic stabilization of the attitude and altitude of the research model was achieved at a satisfactory level. Author

A89-24500
FLIGHT MANAGEMENT PROCEDURES FOR NOISE-MINIMAL LANDING TRAJECTORIES WITH CONSIDERATION OF TEMPERATURE AND WIND GRADIENTS
H. G. JACOB (Honeywell Regelsysteme GmbH, Maintal, Federal Republic of Germany) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 255-261. refs

The future world-wide installation of the MLS will permit a four-dimensional (including time) guidance of aircraft in the airport area with the combined advantages of safer, more economical flight paths with less detrimental environmental impact (noise). This paper demonstrates that the introduction of these advanced navigation and flight guidance technologies will make it possible to compute and to apply continuously time-dependent command inputs for an aircraft to minimize noise. Factors considered included not only the location and population density of living areas along the approach trajectory but also the effects of temperature and wind gradients on noise propagation. Author

A89-24501
OPTIMAL RANGE PERFORMANCE CONTROL OF AIRCRAFT
I. D. ZAPRIANOV, D. I. BOIADZHIEV, and L. K. MIKHAILOV (B'lgarska Akademiia na Naukite, Tsentralna Laboratoriia po Sistemi za Upravlenie, Sofia, Bulgaria) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 263-266. refs

Control techniques for minimizing the fuel consumption of large subsonic transport aircraft are described and demonstrated. A simple point-mass model of aircraft longitudinal motion is outlined; a control procedure based on maintaining an optimal angle of attack is derived; and its implementation in a microprocessor-driven on-board system is briefly characterized. Typical optimal range/velocity curves for altitudes 8000 and 10,000 m, wind velocities from -50 to +50 m/sec, and takeoff weights 70-100 t are presented. T.K.

A89-24526* Rice Univ., Houston, TX.
TRANSFORMATION TECHNIQUES FOR MINIMAX OPTIMAL CONTROL PROBLEMS AND THEIR APPLICATION TO OPTIMAL FLIGHT TRAJECTORIES IN A WINDSHEAR - OPTIMAL ABORT LANDING TRAJECTORIES
A. MIELE, T. WANG (Rice University, Houston, TX), W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA), and C. Y. TZENG IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 8. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 131-150. Research supported by the Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)

The optimal-control problem of abort-landing trajectories in the presence of low-altitude wind shear is investigated analytically. The vertical-plane Newtonian motion of a point-mass aircraft in a steady wind field is modeled, and a sequential gradient-restoration algorithm is applied. Numerical results showing the effects of wind-shear intensity, initial altitude, and power-setting rate are presented in extensive graphs and discussed in detail. Optimal trajectories for strong or severe wind shears are found to begin with a descent, followed by level flight and then an ascent after leaving the shear region. T.K.

A89-24529
AIRCRAFT MANEUVER OPTIMIZATION UNDER FUEL CONSTRAINTS - A REAL TIME ALGORITHM
W. GRIMM (DFVLR, Institut fuer Dynamik der Flugsysteme, Wessling, Federal Republic of Germany) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 8. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 187-192. refs

The paper deals with the optimal flight of an aircraft in a fuel-constrained intercept maneuver. After a preliminary study of the problem itself, an algorithm for real-time optimization is presented. It is based on a reduced system of the state equations, where the direction of the velocity vector is treated as control. For some boundary conditions the flight path controlled by the feedback guidance is compared to the open-loop solution of the optimal-control problem; close agreement between the two types of trajectories is observed. Author

A89-24854
ADVANCES IN FLYING CONTROL SYSTEMS
B. G. S. TUCKER (GEC Avionics, Ltd., Rochester, England) IN: Civil avionics - The future international scene; Proceedings of the Symposium, London, England, Mar. 17, 1988. London, Royal Aeronautical Society, 1988, p. 29-47. refs

A development history and current status account is given for the control systems employed by large commercial aircraft, and prospective developments are characterized. Next-generation aircraft, begining with the A320 airliner, will incorporate such features as distributed data processing, smart actuation, and optical transmission of signals ('fly-by-light'). Attention is given to the bases of control system integrity, the use of digital computers, and the advantages of fly-by-wire technologies currently being implemented. O.C.

N89-15116*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT TESTS OF THREE-DIMENSIONAL PATH-REDEFINITION ALGORITHMS FOR TRANSITION FROM RADIO NAVIGATION (RNAV) TO MICROWAVE LANDING SYSTEM (MLS) NAVIGATION WHEN FLYING AN AIRCRAFT ON AUTOPILOT
RICHARD M. HUESCHEN 1988 23 p
(NASA-TM-4089; L-16458; NAS 1.15:4089) Avail: NTIS HC A03/MF A01 CSCL 01C

This report contains results of flight tests for three path update algorithms designed to provide smooth transition for an aircraft guidance system from DME, VORTAC, and barometric navaids to the more precise MLS by modifying the desired 3-D flight path. The first algorithm, called Zero Cross Track, eliminates the discontinuity in cross-track and altitude error at transition by designating the first valid MLS aircraft position as the desired first waypoint, while retaining all subsequent waypoints. The discontinuity in track angle is left unaltered. The second, called Tangent Path, also eliminates the discontinuity in cross-track and altitude errors and chooses a new desired heading to be tangent to the next oncoming circular arc turn. The third, called Continued Track, eliminates the discontinuity in cross-track, altitude, and track angle errors by accepting the current MLS position and track angle as the desired ones and recomputes the location of the next waypoint. The flight tests were conducted on the Transportation Systems Research Vehicle, a small twin-jet transport aircraft modified for research under the Advanced Transport Operating Systems program at Langley Research Center. The flight tests showed that the algorithms provided a smooth transition to MLS. Author

N89-15118*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IN-FLIGHT SIMULATION INVESTIGATION OF ROTORCRAFT PITCH-ROLL CROSS COUPLING
DOUGLAS C. WATSON and WILLIAM S. HINDSON Dec. 1988 41 p
(NASA-TM-101059; A-89016; NAS 1.15:101059) Avail: NTIS HC A03/MF A01 CSCL 01C

An in-flight simulation experiment investigating the handling qualities effects of the pitch-roll cross-coupling characteristic of single-main-rotor helicopters is described. The experiment was conducted using the NASA/Army CH-47B variable stability helicopter with an explicit-model-following control system. The research is an extension of an earlier ground-based investigation conducted on the NASA Ames Research Center's Vertical Motion Simulator. The model developed for the experiment is for an unaugmented helicopter with cross-coupling implemented using physical rotor parameters. The details of converting the model from the simulation to use in flight are described. A frequency-domain comparison of the model and actual aircraft responses showing the fidelity of the in-flight simulation is described. The evaluation task was representative of nap-of-the-Earth maneuvering flight. The results indicate that task demands are important in determining allowable levels of coupling. In addition, on-axis damping characteristics influence the frequency-dependent characteristics of coupling and affect the handling qualities. Pilot technique, in terms of learned control crossfeeds, can improve performance and lower workload for particular types of coupling. The results obtained in flight corroborated the simulation results. Author

N89-15119# Royal Air Force Coll., Cranwell (England). Dept. of Electrical and Electronic Engineering.
APPLICATION OF FORSYTHE METHOD IN STABILIZING AND DECOUPLING SPEED AND HEIGHT IN F4 PHANTOM AIRCRAFT M.S. Thesis
R. J. THOMASSON 1988 167 p Prepared in cooperation with Loughborough Univ. of Technology (England)
(ETN-89-93566) Avail: NTIS HC A08/MF A01

Output feedback and cascade compensation are used to develop the control system. Solutions are numerically evaluated for three points in the flight envelope: Point A Mach 0.2 at sea level, point B Mach 1.1 at sea level, and point C Mach 1.8 at 16764 m. The methodology is basically a frequency response approach, use being made of root locus diagrams and Nyquist plots. The acceptability of the solutions was verified by setting a digital simulation. The results show that the Forsythe method is apt to achieve stabilization and decoupling using relatively simple compensation elements. ESA

N89-15120# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
STATISTICAL PROPERTIES OF ATMOSPHERIC TURBULENCE RELEVANT TO THE CALCULATION OF AIRPLANE LOADS
R. NOBACK 22 Jan. 1988 103 p
(Contract OV/RLD-737)
(NLR-TR-88013-U; ETN-89-93892) Avail: NTIS HC A06/MF A01

Measured time histories of atmospheric turbulence were analyzed. Distribution functions and exceedance curves of the turbulence and its derivative are presented. The load exceedance curves of various mathematical airplane models due to these turbulence patches were calculated. Deviations of the properties of these patches from the assumed properties used in the power spectral density method are investigated. ESA

N89-15121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DETERMINATION OF LONGITUDINAL AERODYNAMIC DERIVATIVES USING FLIGHT DATA FROM AN ICING RESEARCH AIRCRAFT
R. J. RANAUDO, J. G. BATTERSON, A. L. REEHORST, T. H. BOND, and T. M. OMARA (George Washington Univ., Washington, DC.) 1989 19 p Presented at the 27th Aerospace Sciences Meeting, Reno, NV, 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-101427; E-4528; NAS 1.15:101427; AIAA-89-0754)
Avail: NTIS HC A03/MF A01 CSCL 01C

A flight test was performed with the NASA Lewis Research Center's DH-6 icing research aircraft. The purpose was to employ

a flight test procedure and data analysis method, to determine the accuracy with which the effects of ice on aircraft stability and control could be measured. For simplicity, flight testing was restricted to the short period longitudinal mode. Two flights were flown in a clean (baseline) configuration, and two flights were flown with simulated horizontal tail ice. Forty-five repeat doublet maneuvers were performed in each of four test configurations, at a given trim speed, to determine the ensemble variation of the estimated stability and control derivatives. Additional maneuvers were also performed in each configuration, to determine the variation in the longitudinal derivative estimates over a wide range of trim speeds. Stability and control derivatives were estimated by a Modified Stepwise Regression (MSR) technique. A measure of the confidence in the derivative estimates was obtained by comparing the standard error for the ensemble of repeat maneuvers, to the average of the estimated standard errors predicted by the MSR program. A multiplicative relationship was determined between the ensemble standard error, and the averaged program standard errors. In addition, a 95 percent confidence interval analysis was performed for the elevator effectiveness estimates, C sub m sub delta e. This analysis identified the speed range where changes in C sub m sub delta e could be attributed to icing effects. The magnitude of icing effects on the derivative estimates were strongly dependent on flight speed and aircraft wing flap configuration. With wing flaps up, the estimated derivatives were degraded most at lower speeds corresponding to that configuration. With wing flaps extended to 10 degrees, the estimated derivatives were degraded most at the higher corresponding speeds. The effects of icing on the changes in longitudinal stability and control derivatives were adequately determined by the flight test procedure and the MSR analysis method discussed herein. Author

N89-15122*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.

PREDICTION OF FORCES AND MOMENTS FOR FLIGHT VEHICLE CONTROL EFFECTORS: WORKPLAN Progress Report

MARK D. MAUGHMER Jan. 1989 41 p

(Contract NAG1-849)

(NASA-CR-184666; NAS 1.26:184666) Avail: NTIS HC A03/MF A01 CSCL 01C

Two research activities directed at hypersonic vehicle configurations are currently underway. The first involves the validation of a number of classical local surface inclination methods commonly employed in preliminary design studies of hypersonic flight vehicles. Unlike studies aimed at validating such methods for predicting overall vehicle aerodynamics, this effort emphasizes validating the prediction of forces and moments for flight control studies. Specifically, several vehicle configurations for which experimental or flight-test data are available are being examined. By comparing the theoretical predictions with these data, the strengths and weaknesses of the local surface inclination methods can be ascertained and possible improvements suggested. The second research effort, of significance to control during take-off and landing of most proposed hypersonic vehicle configurations, is aimed at determining the change due to ground effect in control effectiveness of highly swept delta planforms. Central to this research is the development of a vortex-lattice computer program which incorporates an unforced trailing vortex sheet and an image ground plane. With this program, the change in pitching moment of the basic vehicle due to ground proximity, and whether or not there is sufficient control power available to trim, can be determined. In addition to the current work, two different research directions are suggested for future study. The first is aimed at developing an interactive computer program to assist the flight controls engineer in determining the forces and moments generated by different types of control effectors that might be used on hypersonic vehicles. The first phase of this work would deal in the subsonic portion of the flight envelope, while later efforts would explore the supersonic/hypersonic flight regimes. The second proposed research direction would explore methods for determining the aerodynamic trim drag of a generic hypersonic flight vehicle and ways in which it can be minimized through vehicle design and trajectory optimization. Author

N89-15123*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

DERIVATION AND DEFINITION OF A LINEAR AIRCRAFT MODEL

EUGENE L. DUKE, ROBERT F. ANTONIEWICZ, and KEITH D. KRAMBEER Aug. 1988 106 p

(NASA-RP-1207; H-1391; NAS 1.61:1207) Avail: NTIS HC A06/MF A01 CSCL 01C

A linear aircraft model for a rigid aircraft of constant mass flying over a flat, nonrotating earth is derived and defined. The derivation makes no assumptions of reference trajectory or vehicle symmetry. The linear system equations are derived and evaluated along a general trajectory and include both aircraft dynamics and observation variables. Author

N89-15600*# Titan Systems, Inc., Gardena, CA.

CONCEPTS FOR AUTONOMOUS FLIGHT CONTROL FOR A BALLOON ON MARS

THOMAS F. HEINSHEIMER, ROBYN C. FRIEND, and NEIL G. SIEGEL (Siegel, Neil G., Redondo Beach, CA) *In* NASA, Marshall Space Flight Center, Fourth Conference on Artificial Intelligence for Space Applications p 391-400 Oct. 1988

Avail: NTIS HC A21/MF A01 CSCL 01A

Balloons operating as airborne rovers have been suggested as ideal candidates for early exploration of the Martian surface. An international study team composed of scientists from the U.S.S.R., France, and the U.S.A. is planning the launching in 1994 of a balloon system to fly on Mars. The current likely design is a dual thermal/gas balloon that consists of a gas balloon suspended above a solar-heated thermal balloon. At night, the thermal balloon provides no lift, and the balloon system drifts just above the Martian surface; the lift of the gas balloon is just sufficient to prevent the science payload from hitting the ground. During the day, the balloon system flies at an altitude of 4 to 5 kilometers, rising due to the added lift provided by the thermal balloon. Over the course of a single Martian day, there may be winds in several directions, and in fact it can be expected that there will be winds simultaneously in different directions at different altitudes. Therefore, a balloon system capable of controlling its own altitude, via an autonomous flight control system, can take advantage of these different winds to control its direction, thereby greatly increasing both its mission utility and its longevity. Author

N89-15925*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ESTIMATION OF LONGITUDINAL STABILITY AND CONTROL DERIVATIVES FOR AN ICING RESEARCH AIRCRAFT FROM FLIGHT DATA

JAMES G. BATTERSON and THOMAS M. OMARA (Joint Inst. for Advancement of Flight Sciences, Hampton, VA.) Washington, DC Mar. 1989 24 p

(NASA-TM-4099; L-16478; NAS 1.15:4099) Avail: NTIS HC A03/MF A01 CSCL 01C

The results of applying a modified stepwise regression algorithm and a maximum likelihood algorithm to flight data from a twin-engine commuter-class icing research aircraft are presented. The results are in the form of body-axis stability and control derivatives related to the short-period, longitudinal motion of the aircraft. Data were analyzed for the baseline (uniced) and for the airplane with an artificial glaze ice shape attached to the leading edge of the horizontal tail. The results are discussed as to the accuracy of the derivative estimates and the difference between the derivative values found for the baseline and the iced airplane. Additional comparisons were made between the maximum likelihood results and the modified stepwise regression results with causes for any discrepancies postulated. Author

N89-15926 Princeton Univ., NJ.
THEORY AND DEVELOPMENT OF ADAPTIVE FLIGHT CONTROL SYSTEMS USING NONLINEAR INVERSE DYNAMICS Ph.D. Thesis
STEPHEN HARRIS LANE 1988 245 p
Avail: Univ. Microfilms Order No. DA8816048

Aircraft in extreme flight conditions such as stalls and spins encounter severe nonlinearities generated from high angles of attack and high angular rates. Ignoring these nonlinear effects during the development of the flight control system reduces the system's safety margins and increases the pilot's workload as the plane is flown close to the edges of the flight envelope. Flight control systems based on nonlinear inverse dynamics offer the potential for providing improved levels of performance over competing designs developed using linearization assumptions. Inverse dynamics are generated for specific command variable sets of a 12-state nonlinear aircraft model to develop a control system which is valid over the entire flight envelope. Detailed descriptions of the inertial dynamic and aerodynamic models are given; it is shown how the command variable sets are altered as a function of the system state to add stall prevention features to the system. Implementation issues are examined, and simulation results are presented for various mission objectives over a range of flight conditions. These results indicate that improvements in handling qualities, tracking capabilities, and operational safety at high angles of attack are possible with a flight control system designed using a nonlinear inverse dynamics approach.
Dissert. Abstr.

N89-15928*# Boeing Commercial Airplane Co., Seattle, WA.
INTEGRATED AUTOPILOT/AUTOTHROTTLE FOR THE NASA TSRV B-737 AIRCRAFT: DESIGN AND VERIFICATION BY NONLINEAR SIMULATION Final Report
KEVIN R. BRUCE Washington, DC Feb. 1989 119 p
(Contract NAS1-14880)
(NASA-CR-4217; NAS 1.26:4217) Avail: NTIS HC A06/MF A01 CSCL 01C

An integrated autopilot/autothrottle was designed for flight test on the NASA TSRV B-737 aircraft. The system was designed using a total energy concept and is attended to achieve the following: (1) fuel efficiency by minimizing throttle activity; (2) low development and implementation costs by designing the control modes around a fixed inner loop design; and (3) maximum safety by preventing stall and engine overboost. The control law was designed initially using linear analysis; the system was developed using nonlinear simulations. All primary design requirements were satisfied.
Author

N89-15929*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT CONTROL SYSTEMS DEVELOPMENT AND FLIGHT TEST EXPERIENCE WITH THE HIMAT RESEARCH VEHICLES
ROBERT W. KEMPEL and MICHAEL R. EARLS Jun. 1988 88 p
(NASA-TP-2822; H-1428; NAS 1.60:2822) Avail: NTIS HC A05/MF A01 CSCL 01C

Two highly maneuverable aircraft technology (HiMAT) remotely piloted vehicles were flown a total of 26 flights. These subscale vehicles were of advanced aerodynamic configuration with advanced technology concepts such as composite and metallic structures, digital integrated propulsion control, and ground (primary) and airborne (backup) relaxed static stability, digital fly-by-wire control systems. Extensive systems development, checkout, and flight qualification were required to conduct the flight test program. The design maneuver goal was to achieve a sustained 8-g turn at Mach 0.9 at an altitude of 25,000 feet. This goal was achieved, along with the acquisition of high-quality flight data at subsonic and supersonic Mach numbers. Control systems were modified in a variety of ways using the flight-determined aerodynamic characteristics. The HiMAT program was successfully completed with approximately 11 hours of total flight time.
Author

N89-15930*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A PILOTED EVALUATION OF AN OBLIQUE-WING RESEARCH AIRCRAFT MOTION SIMULATION WITH DECOUPLING CONTROL LAWS
ROBERT W. KEMPEL, WALTER E. MCNEILL, GLENN B. GILYARD, and TRINDEL A. MAINE Nov. 1988 52 p
(NASA-TP-2874; H-1430; NAS 1.60:2874) Avail: NTIS HC A04/MF A01 CSCL 01C

The NASA Ames Research Center developed an oblique-wing research plane from NASA's digital fly-by-wire airplane Oblique-wing airplanes show large cross-coupling in control and dynamic behavior which is not present on conventional symmetric airplanes and must be compensated for to obtain acceptable handling qualities. The large vertical motion simulator at NASA Ames-Moffett was used in the piloted evaluation of a proposed flight control system designed to provide decoupled handling qualities. Five discrete flight conditions were evaluated ranging from low altitude subsonic Mach numbers to moderate altitude supersonic Mach numbers. The flight control system was effective in generally decoupling the airplane. However, all participating pilots objected to the high levels of lateral acceleration encountered in pitch maneuvers. In addition, the pilots were more critical of left turns (in the direction of the trailing wingtip when skewed) than they were of right turns due to the tendency to be rolled into the left turns and out of the right turns. Asymmetric side force as a function of angle of attack was the primary cause of lateral acceleration in pitch. Along with the lateral acceleration in pitch, variation of rolling and yawing moments as functions of angle of attack caused the tendency to roll into left turns and out of right turns.
Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A89-21289
AIRCRAFT CABIN COOLING DEVICE KL-A 50/7 [LUFTFAHRZEUGKABINENKUEHLGERAET KL-A 50/7]
MEINHARD REIMANN (Interflug Gesellschaft fuer internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 5, 1988, p. 177, 178. In German.

The aircraft cabin cooling device KL-A 50/7 has been developed as an electric circuit-dependent portable instrument. The instrument's characteristics and mode of operation are briefly described. The design of the device to make it compatible with aircraft cabins is addressed.
C.D.

A89-22369*# Korean Inst. of Science and Technology, Seoul (South Korea).
VISCOUS EFFECTS ON THE RESONANCE OF A SLOTTED WIND TUNNEL USING FINITE ELEMENTS
IN LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1410-1413. refs
(Contract NGL-05-020-243)

Prompted by the fact that wind tunnel flutter and oscillatory airload measurements are affected by acoustic vibration mode coupling when the model frequency lies near a wind tunnel resonance frequency, a numerical method has been developed for design sensitivity analysis. Solid curves represent the resonant frequency for the slot, without considering the slot's viscosity. While the viscosity effect decreases with increasing slot width, the viscosity effect also decreases as the slot width approaches zero.
O.C.

A89-22941
V-22 TESTING - FLEXING THE OSPREY'S WINGS
ERWIN J. BULBAN Rotor and Wing International (ISSN 0191-6408), vol. 23, Jan. 15, 1989, p. 56-58.

An account is given of the test efforts involved in the qualification of the V-22 tilt-rotor aircraft for initial operation. The test programs underway encompass (1) rotor drive systems; (2) fuel tankage and lines; (3) component static and fatigue strength verification; (4) wing static strength; (5) aeroelastic model behavior; (6) avionics; (7) electrical systems; (8) flight controls; (9) validation of tooling and manufacturing; and (10) static strength of an entire airframe, including wings and engine nacelles. Attention is given to the configurations of the test facilities and apparatus. O.C.

A89-23312#
TECHNOLOGICAL IMPROVEMENTS OF RIGS FOR STRUCTURAL TESTING OF COMPLEX EH 101 HELICOPTER COMPONENTS
A. BRIVIO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 10 p.

Recent attempts at improving test rig equipment are discussed. Of particular interest is the mechanical/hydraulic segment of the test rigs. Consideration is also given to the electronic control systems and the stress analysis instrumentation. K.K.

A89-23814
ADAPTIVE MEASURING SECTION IN GOETTINGEN [ADAPTIVE MESSSTRECKEN IN GOETTINGEN]
HARTMUT HOLST (DFVLR, Goettingen, Federal Republic of Germany), ERICH WEDEMEYER, JOCHEN AMECKE, and ALFRED HEDDERGOTT (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 37-39. In German. refs

The influence of wind tunnel wall interference causes measurement results obtained in tunnels to differ significantly from those obtained in free flight. In this paper, steps taken in the Goettingen wind tunnel to adapt wall contours in order to minimize wall interference are described. The use of a two-dimensional adaptive measurement section for three-dimensional modeling is described, and a two-dimensional measurement section with regulable slits is examined. C.D.

A89-24499
FLIGHT SIMULATORS - SIMPLE OR COMPLEX
DANIEL B. DEBRA (Stanford University, CA) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 219, 220. refs

The current status of flight-simulator technology is briefly surveyed, with a focus on the relationship between the level of complexity and the cost. The high cost of video displays, especially for daytime scenes, is discussed, and the capabilities of the most sophisticated simulators are summarized. It is suggested that more rudimentary systems with simple displays (even those comprising only instrument readings) are sufficient for many hardware-evaluation tasks, but that pilot training often requires the performance of state-of-the-art simulators. T.K.

N89-15124# Dundee Univ. (Scotland). Dept. of Civil Engineering.
ALTERNATIVE MODIFIED BINDERS FOR AIRFIELD PAVEMENTS Final Report, Aug. 1986 - Mar. 1988
A. F. STOCK Mar. 1988 106 p
(Contract DAJA45-86-C-0043; DA PROJ. 1L1-61102-BH-57)
(AD-A197902; R/D-5499-EN-01) Avail: NTIS HC A06/MF A01 CSCL 13B

The technical object of this research was to investigate materials, to modify, augment, extend and/or replace conventional asphalt cement binders for flexible airfield pavements, capable to sustain aircraft tire pressures of 350/400 psi. This study looked at a number of alternate materials and modified materials to determine their acceptability for producing the mixtures. There was a thorough review of the published literature concerning additive types, their effect on the properties of binders and mixers. Selection of a series of test procedures and development of a testing program to screen additives for their suitability for combination with bitumen, determine mix design procedures, and to measure the structural and mechanical properties of mixes was done. It may be concluded that aircraft fitted with vectored thrust can cause additional structural damage to pavements as a result of heating effects. It is also concluded that erosion is possible as a result of the blast from the vectored thrust. It is recommended that the operating parameters of aircraft using vectored thrust be investigated as this has considerable significance in relation to the damage potential. The analysis in this report provides sufficient data for a preliminary assessment of the probability of damage, therefore permitting a decision in relation to further investigation. GRA

N89-15126# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
TECHNOLOGY INVOLVED IN THE SIMULATION OF MOTION CUES: THE CURRENT TREND
H. A. MOOIJ 30 Sep. 1987 19 p Presented at the AGARD Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Sickness, Brussels, Belgium, 28 Sep. - 2 Oct. 1987
(NLR-MP-87060-U; ETN-89-93885) Avail: NTIS HC A03/MF A01

Flight simulators and simulator sickness are introduced, and trends in visual and motion systems are reviewed. The basic cueing methodology in flight simulation, and developments in image generation, image display, platform motion cue generation, and motion hardware mechanisms are discussed. The importance of maintenance and calibration of flight simulator installations is mentioned. ESA

N89-15127# European Space Agency, Paris (France).
THE TRANSONIC WIND TUNNEL (TWB) AT DFVLR IN BRAUNSCHWEIG (FEDERAL REPUBLIC OF GERMANY) Status Report, 1987
WOLFGANG PUFFERT-MEISSNER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) Nov. 1988 45 p Transl. into ENGLISH of Der Transsonische Windkanal (TWB) der DFVLR in Braunschweig (Brunswick, Fed. Republic of Germany, DFVLR), Dec. 1987 47 p Original language document was announced as N88-22909
(ESA-TT-1114; DFVLR-MITT-88-01; ETN-89-93908) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 30.50 Deutsche marks

The transonic wind tunnel Braunschweig is a pressurized blowdown wind tunnel. The test section for two-dimensional airfoil testing has an area of 0.34 x 0.60 m. Mach number range is from 0.3 to 0.95 and Reynolds number range from 2,900,000 to 12 million at Mach 0.7, based on an airfoil chord length of 150 mm. Information required for the preliminary planning of test programs and for preliminary layout of models used in such programs is given. ESA

N89-15931# Army Cold Regions Research and Engineering Lab., Hanover, NH.
HARD-SURFACE RUNWAYS IN ANTARCTICA
MALCOLM MELLOR Aug. 1988 90 p
(AD-A200444; CRREL-SR-88-13) Avail: NTIS HC A05/MF A01 CSCL 01E

The feasibility of constructing and maintaining hard-surface snow runways at McMurdo Sound and the South Pole was studied. Existing technology was reviewed, and proposals for novel techniques and machines were put forward. It was concluded that all-season operation of heavy wheeled aircraft from snow runways is not a practical proposition for the short term. Other possibilities for all-season operation of wheeled aircraft were considered. These included: (1) a conventional runway of rock-fill and gravel, (2) rock-fill and gravel over permanent ice, (3) a runway on coastal

glacier ice, and (4) runways on bare glacier ice at inland locations. Rough cost estimates were made for each of the runway types that were considered. After examining the trends in Antarctic aviation, the following recommendations were offered: (1) develop a construction plan for a conventional runway at Marble Point; (2) proceed with site selection, equipment design, and development of ground transport for a wheel runway on the Ross Ice Shelf; and (3) search for natural blue ice airfields at inland locations, especially locations that are not too far from the South Pole.
GRA

N89-15932*# Eloret Corp., Sunnyvale, CA.
A RESEARCH STUDY FOR THE PRELIMINARY DEFINITION OF AN AEROPHYSICS FREE-FLIGHT LABORATORY FACILITY
THOMAS N. CANNING 1988 19 p
(Contract NCC2-504)
(NASA-CR-184631; NAS 1.26:184631) Avail: NTIS HC A03/MF A01 CSCL 14B

A renewed interest in hypervelocity vehicles requires an increase in the knowledge of aerodynamic phenomena. Tests conducted with ground-based facilities can be used both to better understand the physics of hypervelocity flight, and to calibrate and validate computer codes designed to predict vehicle performance in the hypervelocity environment. This research reviews the requirements for aerothermodynamic testing and discusses the ballistic range and its capabilities. Examples of the kinds of testing performed in typical high performance ballistic ranges are described. We draw heavily on experience obtained in the ballistics facilities at NASA Ames Research Center, Moffett Field, California. Prospects for improving the capabilities of the ballistic range by using advanced instrumentation are discussed. Finally, recent developments in gun technology and their application to extend the capability of the ballistic range are summarized. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A89-21558
A PHYSICOMATHEMATICAL MODEL OF THE INTERNAL FILM COOLING OF CONTROL ENGINES OPERATING IN THE PULSED MODE [FIZIKO-MATEMATICHESKAIA MODEL' VNUTRENNEGO PLENOCHNOGO OKHLAZHDENIIA DVIGATELEI UPRAVLENIIA DLIA IMPUL'SNOGO REZHIMA RABOTY]
N. N. KOVAL'NOGOV and V. L. ROMANOVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 34-38. In Russian.

Physical and mathematical models of the internal film cooling of control engines operating in the pulsed mode are presented which make it possible to calculate the boundary conditions of heat transfer and the thermal state of the combustion chamber. Calculations are carried out for a specific example. It is shown that, thermally, the pulsed regime is more rigorous than the continuous operation mode. V.L.

A89-24068
PAST PROGRESS AND FUTURE ADVANCES IN SPACE LASER COMMUNICATIONS
MONTE ROSS IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 527-532.

The history of space laser communication is sketched. Three steps to establishing a link between pplatforms-acquisition, tracking, and communication-are described. It is suggested that future advances will greatly ease the tight tolerance requirements and bring down laser communication terminal costs as well as allow small apertures characteristic of space-based systems. This forecast based on rapid advances in semiconductor laser technology, especially at the GaAs laser wavelength. Also important will be the use of wide beams and smaller optics, coherent laser arrays, systems-on-a-chip, and MOCVD growth technology. Technology advances will make systems smaller, lighter, and far less expensive. I.E.

N89-15160# European Space Agency, Paris (France).
DESIGN, SIMULATION AND LABORATORY TEST OF AN INERTIAL SYSTEM FOR MEASURING THE ATTITUDE AND NARROW-SPACED MOTIONS
BERNHARD STEILER, EGMAR LUEBECK, and VOLKER WETZIG (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) Nov. 1988 196 p Transl. into ENGLISH of Ausleng, Simulation und Laborerprobung eines Interialsystems zur Vermessung der Winkellage und Kleinraeumiger Bewegungsablaeufe (Brunswick, Fed. Republic of Germany, DFVLR) Original language document was announced as N88-21426
(ESA-TT-1104; DFVLR-FB-87-42; ETN-89-93906) Avail: NTIS HC A09/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 62 Deutsche marks

A system for accurately measuring the attitude of an aircraft model under dynamic conditions in a wind tunnel was developed. Accuracy is within 0.03 deg using strapdown sensors of limited quality. The system also allows accurate measurement of fast narrow-spaced motions. Sensor errors are calibrated while the system is at rest, and their constant part is compensated during the measurement phase. ESA

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A89-22227
THE ROLE OF MIXING AND KINETICS IN HEAT RELEASE DECREASE IN THE SUPERSONIC COMBUSTION OF UNMIXED GASES IN EXPANDING DUCTS [ROL' SMESHENIIA I KINETIKI V UMEN'SHENII TEPLOVYDELENIIA PRI SVERKHZVUKOVOM GORENII NEPEREMESHANNYKH GAZOV V RASSHIRIAIUSHCHIKHSIA KANALAKH]
E. A. MESHCHERIAKOV and V. A. SABEL'NIKOV Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 24, Sept.-Oct. 1988, p. 23-32. In Russian. refs

The factors responsible for the retardation of the supersonic combustion of unmixed gases in slightly expanding ducts are investigated analytically. By using Zeldovich's theory and numerical integration of the conservation equations of a multicomponent reacting gas mixture in turbulent flow, it is shown that, for the practically important range of chamber inlet conditions, the retardation of combustion is due to the intense mixing of components. Possible methods of overcoming this effect are examined. V.L.

A89-22277*# Drexel Univ., Philadelphia, PA.
DEGRADATION MECHANISMS OF N-DODECANE WITH SULFUR AND NITROGEN DOPANTS DURING THERMAL STRESSING
K. T. REDDY, N. P. CERNANSKY (Drexel University, Philadelphia, PA), and R. S. COHEN (Temple University, Philadelphia, PA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5,

Jan.-Feb. 1989, p. 6-13. Research supported by Drexel University. Previously cited in issue 20, p. 3192, Accession no. A87-45372. refs
(Contract NAG3-183)

A89-22613
RADIATION-CURABLE CARBON FIBER PREPREG COMPOSITES
CHRIS B. SAUNDERS, LAWRENCE W. DICKSON, AJIT SINGH, ALISTAIR A. CARMICHAEL, and VINCE J. LOPATA (Whiteshell Nuclear Research Establishment, Pinawa, Canada) Polymer Composites (ISSN 0272-8397), vol. 9, Dec. 1988, p. 389-394; Discussion, p. 394. refs

A radiation-curable prepreg designed to meet the specifications set by a major aircraft company is described. The resin, consisting of a mixture of an epoxy diacrylate, polybutadiene diacrylate, and a multifunctional monomer, was used to impregnate a plain weave carbon fabric by a solvent process. The cured polymer, produced by irradiation in air to a dose of 40 kGy, is amorphous, with a gel fraction of 85 percent. The linear thermal expansion coefficient of the polymer was found to be 0.00017 m/m deg C from 25 to 150 C; it was not affected by varying the applied irradiation dose from 30 to 50 kGy. I.S.

A89-22890#
CREEP BEHAVIOUR OF CARBON FIBRE REINFORCED POLYETHERETHERKETONE AND EPOXY RESIN
A. HOROSCHENKOFF, J. BRANDT, J. WARNECKE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany), and O. S. BRUELLER (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) SAMPE, European Meeting, Milan, Italy, June 14-16, 1988, Paper. 12 p. refs
(MBB-Z-178/88-PUB)

The tensile creep behavior of two high-performance carbon-fiber-reinforced composites was studied. Laminates with PEEK and epoxy-resin matrices were used. The results of two different laminate lay-ups are presented: a quasi-isotropic laminate simulating aircraft structures, and a matrix-dominated lay-up. In the case of quasi-isotropic laminate lay-up, no significant differences in the viscoelastic response between PEEK and epoxy-resin composites under tensile creep load conditions at room temperature could be found. K.K.

A89-22928
FUELS
WILLIAM F. TAYLOR (Exxon Research and Engineering Co., Florham Park, NJ) Exxon Air World, vol. 40, no. 3, 1988, p. 29, 30.

An account is given of current thinking on the infrastructural development prospects and the economic viability of such advanced cryogenic fuels as liquid hydrogen and liquid methane, as well as exotic synthetic liquid hydrocarbon fuels. The family of endothermic fuels will turn supersonic aircraft into flying chemical reactors, as they absorb airframe aerothermodynamic heat to change in chemical composition while actively cooling the structure. The airport-infrastructural and aircraft configuration-related difficulties posed by cryogenic fuels are noted. O.C.

A89-23027
BREAKING WITH TRADITION
Advanced Materials and Processes (ISSN 0882-7958), vol. 135, Jan. 1989, p. 59-62, 65, 66.

An evaluation is made of the current development status and market penetration of polymeric-matrix composites and the extent of their prospective market share expansions at the expense of more traditional aluminum alloy-based structures. The current and anticipated proportions of polymer composite-to-metallic structural masses for several categories of civilian and military aircraft are noted. The development of polymer composites based on such thermoplastic matrix resins as bismaleimides, which can sustain operating environment temperatures of the order of 310 C, may compete with titanium alloys in several supersonic aircraft applications. O.C.

A89-23891#
FLAME FLASHBACK FOR LOW REYNOLDS NUMBER FLOWS
G. A. KARIM (Calgary, University, Canada) and R. LAPUCHA (Instytut Lotnictwa, Warsaw, Poland) IN: Dynamics of reactive systems. Part 1: Flames; International Colloquium on Dynamics of Explosions and Reactive Systems, 11th, Warsaw, Poland, Aug. 3-7, 1987, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 367-383. Research supported by NSERC. refs

Flame flashback in a coflowing homogeneously mixed air-fuel stream has been experimentally investigated for stream Reynolds numbers of up to 6000. The critical angles of the leading edge of the flame front are used along with an idealized model of the flame flashback shape to determine the velocities of the propagating flame at flashback. Results are given for the combustion efficiency of the system for flow conditions near the flame flashback limits. R.R.

N89-15187*# Boeing Commercial Airplane Co., Seattle, WA. Advanced Composite Development Program.
DAMAGE TOLERANT COMPOSITE WING PANELS FOR TRANSPORT AIRCRAFT
PETER J. SMITH, ROBERT D. WILSON, and M. N. GIBBINS Washington NASA Dec. 1985 60 p
(Contract NAS1-16863)
(NASA-CR-3951; NAS 1.26:3951) Avail: NTIS HC A04/MF A01 CSCL 11D

Commercial aircraft advanced composite wing surface panels were tested for durability and damage tolerance. The wing of a fuel-efficient, 200-passenger airplane for 1990 delivery was sized using grahite-epoxy materials. The damage tolerance program was structured to allow a systematic progression from material evaluations to the optimized large panel verification tests. The program included coupon testing to evaluate toughened material systems, static and fatigue tests of compression coupons with varying amounts of impact damage, element tests of three-stiffener panels to evaluate upper wing panel design concepts, and the wing structure damage environment was studied. A series of technology demonstration tests of large compression panels is performed. A repair investigation is included in the final large panel test. B.G.

N89-15198# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
FATIGUE DAMAGE IN COMPOSITES UNDER DIFFERENT LOADING CONDITIONS
W. G. J. THART 25 Feb. 1988 42 p
(Contract NIVR-1744)
(NLR-TR-88032-U; ETN-89-93893) Avail: NTIS HC A03/MF A01

The damage development in notched (+ or - 45, O2, 90, O2)s carbon-epoxy coupon specimens tested under different loading conditions was determined. Constant amplitude tests at R = 1 and R = 0.1 as well as flight simulation tests were performed to establish stress values for which no damage growth occurs. Constant amplitude testing reveals fatigue limits for no damage growth at 1 million cycles, of 133 MPa and 267 MPa, respectively. Literature data for equivalently notched 2024-T3 are 90 MPa and 135 MPa for similar stress ratios. Flight simulation tests using MINI-TWIST and a block program approximating the cumulative frequency distribution of MINI-TWIST results in a mean stress level of 133 MPa at which no damage growth occurs. At this stress level the fatigue life of equivalently notched 2024-T3 is 5000 flights. Constant amplitude testing at R = -1 shows the most reproduceable fatigue damage development. Therefore testing at R = -1 seems to be the most appropriate for selecting materials on the basis of resistance to delamination damage growth. ESA

N89-15249# Sandia National Labs., Albuquerque, NM.
SUMMARY OF AGING EFFECTS ON 25-YEAR OLD NYLON PARACHUTES

E. L. TADIOS 1988 10 p Presented at the 10th AIAA Aerodynamic Decelerator Systems Technology Conference, Cocoa Beach, FL, 18 Apr. 1988
(Contract DE-AC04-76DP-00789)
(DE89-001378; SAND-88-2494C; CONF-8804204-1) Avail: NTIS HC A02/MF A01

Structural evaluations were conducted on several parachute systems to determine the effects of aging on parachute materials. Most of the parachutes were 25 years old. Five 64 ft parachutes were evaluated along with one 4 ft guide surface parachute and three 16.5 ft ribbon parachutes. The parachute systems used in the study were all fabricated from nylon materials. Results were obtained for several material properties such as tensile strength, air permeability and melting point. Military specifications were used as zero-time data base due to lack of raw material data. The results indicate that over a period of about 25 years, parachute nylon materials do not degrade to unacceptable levels. DOE

N89-15251*# Ford Motor Co., Dearborn, MI. Scientific Lab.
IMPROVED SILICON CARBIDE FOR ADVANCED HEAT ENGINES Annual Report
T. J. WHALEN and W. L. WINTERBOTTOM Sep. 1986 103 p
(Contract NAS3-24384)
(NASA-CR-179477; NAS 1.26:179477) Avail: NTIS HC A06/MF A01 CSCL 11C

Work performed to develop silicon carbide materials of high strength and to form components of complex shape and high reliability is described. A beta-SiC powder and binder system was adapted to the injection molding process and procedures and process parameters developed capable of providing a sintered silicon carbide material with improved properties. The initial effort has been to characterize the baseline precursor materials (beta silicon carbide powder and boron and carbon sintering aids), develop mixing and injection molding procedures for fabricating test bars, and characterize the properties of the sintered materials. Parallel studies of various mixing, dewaxing, and sintering procedures have been carried out in order to distinguish process routes for improving material properties. A total of 276 MOR bars of the baseline material have been molded, and 122 bars have been fully processed to a sinter density of approximately 95 percent. The material has a mean MOR room temperature strength of 43.31 ksi (299 MPa), a Weibull characteristic strength of 45.8 ksi (315 MPa), and a Weibull modulus of 8.0. Mean values of the MOR strengths at 1000, 1200, and 14000 C are 41.4, 43.2, and 47.2 ksi, respectively. Strength controlling flaws in this material were found to consist of regions of high porosity and were attributed to agglomerates originating in the initial mixing procedures. The mean stress rupture lift at 1400 C of five samples tested at 172 MPa (25 ksi) stress was 62 hours and at 207 MPa (30 ksi) stress was 14 hours. New fluid mixing techniques have been developed which significantly reduce flaw size and improve the strength of the material. Initial MOR tests indicate the strength of the fluid-mixed material exceeds the baseline property by more than 33 percent. Author

N89-15281# Cameron Force Co., Houston, TX.
THE APPLICATION OF PROCESS MODELLING TO HEAT TREATMENT OF SUPERALLOYS
R. A. WALLIS, N. M. BHATHENA, P. R. BHOWAL, and E. L. RAYMOND *In* AGARD, Aerospace Materials Process Modelling 15 p Aug. 1988
Avail: NTIS HC A12/MF A01

Quenching experiments have been carried out with a flat disk having thermocouples embedded in it. Cooling curves from such tests have provided input data for an inverse heat conduction model which has been used to determine the relationship between the heat transfer coefficient and the part surface temperature for different quenching media. The coefficients obtained have been used in finite element models to predict the temperature and stress distribution within components during heat treatment. The quenching models were validated by trials carried out with instrumented subscale and full size turbine disk forgings. The models have been used to determine the quenching media required to give the cooling rates necessary to meet the property specifications for superalloy components. They have also been used, qualitatively, to reduce the residual stresses developed during quenching with a subsequent reduction in distortion problems during machining. A further application has been the elimination of cracking during the quenching of crack sensitive alloys. Author

N89-16031# General Dynamics Corp., Fort Worth, TX.
EVALUATION OF RST (RAPIDLY SOLIDIFIED TECHNOLOGY) STRUCTURAL DURABILITY AND LIFE CYCLE COSTS Final Report, Oct. 1983 - Sep. 1987
W. R. GARVER, D. Y. LEE, and D. E. GORDON 19 Oct. 1987 175 p
(Contract F33615-83-C-3227; AF PROJ. 2401)
(AD-A199336; AFWAL-TR-87-3068) Avail: NTIS HC A08/MF A01 CSCL 11F

The objective is to characterize the structural durability of high strength powder metallurgy (P/M) aluminum alloys. An F-16 aft fuselage bulkhead was chosen as a prime configuration since a preliminary trade study predicted good weight savings for this application. Test specimens were designed to model a critical location in the F-16 FS446 bulkhead. Spectrum fatigue tests were conducted under two types of spectrum load histories, HUD34 and NOR1. HUD34 is a tension-compression type spectrum representing the 500-hour block spectrum for the F-16 FS446 bulkhead, while NOR1 is a tension-dominated type spectrum representing the B-1 wing carry-through box spectrum. GRA

N89-16034# Rockwell International Corp., Los Angeles, CA. Aircraft Div.
SUPERPLASTIC FORMING OF 8091 ALUMINUM LITHIUM Report, Apr. 1987 - Jun. 1988
C. E. ANTONE, G. R. MARTIN, A. K. GHOSH, and G. GANDHI 21 Jun. 1988 18 p
(Contract F33615-87-C-3223)
(AD-A200364; AFWAL-TR-88-3074) Avail: NTIS HC A03/MF A01 CSCL 11F

Aluminum-Lithium alloys have been introduced to the Aerospace community as a way to decrease weight and improve stiffness over conventional aluminum alloys for structural components. A manufacturing method which as created a great deal of interest for Al-Li aerospace applications is the fabrication of net shape parts by superplastic forming (SPF). Aluminum-Lithium alloys present some unique handling problems and fabrication challenges for established practices in superplastic forming. This paper will discuss the manufacturing challenges and approaches of forming 8091 Al-Li by SPF and provide a brief overview into the material characteristic which make 8091 a successful candidate for SPF aircraft parts. GRA

N89-16053# Pratt and Whitney Aircraft, West Palm Beach, FL.
EVALUATION OF CORROSION INHIBITORS AS LUBRICITY IMPROVERS Interim Report No. 2, 16 Feb. 1987 - 15 Feb. 1988
T. B. BIDDLE and W. H. EDWARDS Jul. 1988 163 p
(Contract F33615-85-C-2508)
(AD-A198743; PW/GPD-FR-19031-2; AFWAL-TR-88-2036) Avail: NTIS HC A08/MF A01 CSCL 11F

The corrosion inhibitors (CI) currently approved under the MIL-I-25017D products list (QPL) are discussed. The thrust of the effort focused on the establishment of relative effective concentrations for approved CI, generation of working curves to profile Ci performance in jet fuels, development of an approach for incorporating a lubricity requirement into MIL-I25017, refinement of the reverse phase high performance liquid chromatography (RPHPLC) method for determining Ci content in jet fuels, determination of the applicability of the RPHPLC to WPL CI, and generation of an RPHPLC spectral library of WPL CI in JP-4. IPC-4410 was found to be among the most effective Ci at improving the lubricity properties of jet fuels, while TOLAD 249 was shown to be the least effective. Pratt and Whitney found that a requirement for lubricity enhancement could easily be incorporated into

MIL-I-25017 with no significant effect on other criteria used in qualifying a candidate CI. GRA

N89-16069# Oak Ridge National Lab., TN.
A MODEL FOR ESTIMATING EVAPORATION RATE IN FIXED-ROOF JP-4 FUEL STORAGE TANKS Final Report
C. STUART DAW and NORBERT C. J. CHEN Sep. 1988 29 p (Contract DE-AC05-84OR-21400)
(DE89-004261; ORNL/TM-10952) Avail: NTIS HC A03/MF A01

This report describes a mathematical model that simulates the evaporation of JP-4 fuel in fixed-roof storage tanks. The model is based on fundamental mass-transport processes, thus minimizing the need for empirical parameters. Model predictions are summarized both graphically and algebraically, making it possible to readily estimate the evaporation rate for specific cases. The model predictions are shown to compare favorably with previous field observations. The model also confirms that JP-4 storage tank emissions are usually well below saturation. DOE

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A89-20958#
IN PROCESS FAILURE INVESTIGATIONS IN AERONAUTICS
A. K. DAS and PREM BAVEJA (Hindustan Aeronautics, Ltd., Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Feb. 1988, p. 63-69. Research supported by the Aeronautical Research and Development Board.

The classification of defects is discussed as well as the causes and detection of defects. Inherent defects due to casting include piping, blow holes, nonmetallic inclusions, and segregation. Primary processing defects in wrought products include seams, laminations, and cooling cracks. Secondary processing defects include heat treatment cracks, overheating, and oxidation. Nondestructive testing is considered as well as fractographic examination, mechanical tests, chemical analysis, and metallography. K.K.

A89-21132
INTERNATIONAL CONFERENCE ON COMPUTATIONAL ENGINEERING MECHANICS, BEIJING, PEOPLE'S REPUBLIC OF CHINA, JUNE 21-25, 1987, PROCEEDINGS
LINGXI QIAN, ED., WANXIE ZHONG, ED. (Dalian Institute of Technology, People's Republic of China), and CHO W. S. TO, ED. (Western Ontario, University, London, Canada) Conference sponsored by the Chinese Society of Theoretical and Applied Mechanics. Computers and Structures (ISSN 0045-7949), vol. 30, no. 4, 1988, 243 p. For individual items see A89-21133 to A89-21161.

Computational techniques for engineering mechanics are examined in reviews and reports. Sections are devoted to theoretical developments and new element models, solution strategies and methodology, finite-element analysis and other numerical methods, nonlinear analysis and dynamics, and structural design and applications. Consideration is given to wave-envelope elements for acoustic radiation in inhomogeneous media, numerical simulation of ductile fracture, an adpative dynamic relaxation method for nonlinear problems, subdomain bounding techniques for large-scale shakedown analysis, analysis of thick axisymmetric spherical shells by a finite-spherical-layer method, an element-based Lagrangian formulation for large-deformation analysis, and FEMs and AI on parallel machines. T.K.

A89-21138
LOCAL/GLOBAL STRUCTURAL ANALYSIS BY TRANSITION ELEMENTS
YAONAN GONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) (Chinese Society of Theoretical and Applied Mechanics, International Conference on Computational Engineering Mechanics, Beijing, People's Republic of China, June 21-25, 1987) Computers and Structures (ISSN 0045-7949), vol. 30, no. 4, 1988, p. 831-836.

In the present paper, a transition element is recommended for local/global structural analysis. A short review on different measures for enhancing the efficiency and reducing the cost of the analysis are given. Based on the concept of tying the nodal degrees of freedom of the element, a family of transition elements used in the local/global analysis is constructed, and a criterion for differentiating the local and global areas is suggested. To illustrate the applicability of transition elements to complex structural analysis, numerical examples are given. Author

A89-21156
A FINITE ELEMENT ELASTIC-PLASTIC-CREEP ANALYSIS OF MATERIALS WITH TEMPERATURE DEPENDENT PROPERTIES
XIAYING MU and HURANG HU (Xian Jiaotong University, People's Republic of China) (Chinese Society of Theoretical and Applied Mechanics, International Conference on Computational Engineering Mechanics, Beijing, People's Republic of China, June 21-25, 1987) Computers and Structures (ISSN 0045-7949), vol. 30, no. 4, 1988, p. 953-956.

Based on the classical theory of thermoelastoplasticity, incremental constitutive equations and element equations are derived for a body with temperature-dependent material properties. A computer program for thermoelastoplastic and creep analysis has been developed to compute the creep strains for an axisymmetric body under axisymmetric loads, with satisfactory results. Finally, a stress-strain analysis for the turbine disk of a jet engine is given which can be applied to engineering design. Author

A89-21277
BOUNDARY ELEMENTS X; PROCEEDINGS OF THE TENTH INTERNATIONAL CONFERENCE ON BOUNDARY ELEMENT METHODS, SOUTHAMPTON, ENGLAND, SEPT. 6-9, 1988. VOLUME 2 - HEAT TRANSFER, FLUID FLOW AND ELECTRICAL APPLICATIONS
CARLOS ALBERTO BREBBIA, ED. (Computational Mechanics Institute, Southampton, England) Southampton, England/New York, Computational Mechanics Publications/Springer-Verlag, 1988, 564 p. For individual items see A89-21278 to A89-21286.

Mathematical, computational, and applications aspects of BEMs are examined in reviews and reports. Topics addressed include diffusion and convection, potential problems, heat transfer, fluid mechanics, fluid dynamics, and electronics and electrostatics. Consideration is given to time-dependent fundamental solutions for diffusion BEMs, new software for modeling transient and nonlinear thermal diffusion, a BEM for time-dependent three-dimensional isochoric viscous flow, BEMs for Poisson problems, an alternative iteration method for moving boundary-free flow, radiative heat transfer in cavities, low-order panel methods for vortex-sheet rollup and wing-vortex interaction, prediction of the aerodynamic characteristics of high-lift multielement airfoils, a BEM for semiconductor device analysis, and variational methods for eddy-current problems. T.K.

A89-21288
ELECTRONIC MATERIALS TESTING IN COMMERCIAL AIRCRAFT ENGINES [ELEKTRONISCHE MATERIALPRUEFUNG AN TRIEBWERKEN DER VERKEHRSFLUGZEUGE]
DIETER BRAND (Interflug Gesellschaft fuer internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 5, 1988, p. 167, 168, 172. In German.

A device for the electronic testing of materials used in

commercial aircraft engines is described. The instrument can be used for ferromagnetic, ferrimagnetic, and nonferromagnetic metallic materials, and it functions either optically or acoustically. The design of the device is described and technical data are given. The device operates under the principle of controlled self-inductivity. Its mode of operation is described. C.D.

A89-21480
EFFECT OF PHASE FLUCTUATIONS AND ADDITIVE NOISE ON THE CHARACTERISTICS OF AN SAR [VLIIANIE FAZOVYKH FLUKTUATSII I ADDITIVNOGO SHUMA NA KHARAKTERISTIKI RSA]
N. A. SAZONOV, A. V. OCHEPOVSKII, G. V. ROMANENKO, P. V. FAL'KOVSKII, and A. V. FEDIUNIN Radiotekhnika (ISSN 0033-8486), Oct. 1988, p. 43-47. In Russian. refs

Relationships are derived for estimating the resolution and azimuth-determination accuracy for a synthetic aperture radar under the effect of phase fluctuations of the echo signal and additive noise for arbitrary motions of the flight vehicle and ground objects. It is shown that, under the effect of additive noise, the expectation and variance of the angular position of the object, as well as the duration of the output signal according to the angular parameter, depend on the relationship of the energy characteristics of this noise and the echo signal. B.J.

A89-21553
SOME PARTIAL SOLUTIONS TO THE PROBLEM OF THE OPTIMUM RELIABILITY DISTRIBUTION OF A STRUCTURE WITH RESPECT TO ITS ELEMENTS [O NEKOTORYKH CHASTNYKH RESHENIIAKH ZADACHI OPTIMAL'NOGO RASPREDELENIIA NADEZHNOSTI KONSTRUKTSII MEZHDU EE ELEMENTAMI]
A. M. ARASLANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 14-18. In Russian.

Some partial solutions are presented which make it possible to significantly simplify the general problem of the optimum reliability distribution of a structure with respect to its elements. The solutions are based on certain assumptions concerning the type of the dependence of the weight and reliability of the entire structure on the reliability of its individual elements. Derivations of the solution algorithms are presented. V.L.

A89-21557
A MATHEMATICAL DEFORMATION MODEL FOR VIBRATION ISOLATORS OF MR MATERIAL [MATEMATICHESKAIA MODEL' DEFORMIROVANIIA VIBROIZOLIATOROV IZ MATERIALA MR]
G. V. LAZUTKIN and A. M. ULANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 30-34. In Russian.

A mathematical model is proposed for describing the deformation characteristics of vibration isolators of MR material (a nonwoven porous material made of metal wires) for any set of loading and unloading processes. As an example, the model is used to calculate the deformation characteristics of two types of commercial vibration isolators of MR material. The results are found to be in good agreement with experimental data. V.L.

A89-21562
CHARACTERISTICS OF THE OPERATING PROCESS OF GAS TURBINE ENGINES [O ZAKONOMERNOSTIAKH RABOCHEGO PROTSESSA GTD]
B. D. FISHBEIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 51-55. In Russian.

The dependence of relative pressure changes on relative temperature changes in an arbitrary turbocompressor (e.g., compressor, powerplant, turbine) is examined as a fundamental characteristic of the operating process of an integral unit within a gas turbine. The efficiency of using this characteristic in the analysis of experimental data and in the identification of a mathematical model of an engine is demonstrated by using a bypass engine as an example. V.L.

A89-21575
ESTIMATION OF THE EFFECT OF THE PRINCIPAL DESIGN PARAMETERS OF STAGNATION TEMPERATURE TRANSDUCERS ON MEASUREMENT DELAY [OB OTSENKE VLIIANIIA OSNOVNYKH KONSTRUKTIVNYKH PARAMETROV DATCHIKOV TEMPERATURY TORMOZHENIIA NA INERTSIONNOST' IZMERENIIA]
A. M. SABIRZIANOV, R. KH. LATYPOV, and M. R. MUSIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 93-95. In Russian.

A study is made of the effect of the design of the stagnation chamber, sensitive element, and intake and outlet devices of transverse-flow resistive temperature transducers in aviation gas turbines on the measurement delay. A formula is obtained which makes it possible to determine the effect of the design parameters of the temperature transducers on the measurement delay for a known dependence of the hydraulic drag of the transducer on the structural design and dimensions of the stagnation chamber, sensitive element, and intake and outlet devices. The validity of the method is verified by comparing the results with wind tunnel test data. V.L.

A89-21576
DEVELOPMENT OF A PROCESS FOR THE HEALING OF SURFACE DISCONTINUITIES WITH ALLOWANCE FOR THE CHOICE OF THE DIAGNOSTIC PARAMETERS OF THE ACTUAL CONDITIONS OF GAS TURBINE ENGINE PARTS [PROEKTIROVANIE TEKHNOLOGII ZALECHIVANIIA POVERKHNOSTNYKH NESPLOSHNOSTEI S UCHETOM VYBORA DIAGNOSTICHESKIKH PARAMETROV FAKTICHESKOGO SOSTOIANIIA DETALEI GTD]
S. M. BOROVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1988, p. 96-98. In Russian.

The mechanisms of the closure of surface cracks and other discontinuities under the effect of applied stresses are investigated analytically with a view to developing a process for the healing of surface defects. The physical and structural parameters that are essential for evaluating a process for the healing of defects are identified. The discussion is illustrated by an example involving compressor blades of VT9 titanium alloy. V.L.

A89-21644
GENERALIZATION OF THE RESULTS OF EXPERIMENTAL STUDIES OF THE STABILITY OF GASDYNAMIC-BEARING ROTORS [OBOBSHCHENIE REZUL'TATOV EKSPERIMENTAL'NYKH ISSLEDOVANII USTOICHIVOSTI ROTOROV NA GAZODINAMICHESKIKH PODSHIPNIKAKH]
Z. S. KAUFMAN, B. IA. BRITVAR, and M. I. KREMER (Leningradskii Nauchno-Issledovatel'skii i Konstruktorskii Institut Khimicheskogo Mashinostroeniia, Leningrad, USSR) Priborostroenie (ISSN 0021-3454), vol. 31, Oct. 1988, p. 38-43. In Russian. refs

The main points of a procedure for studying the stability of a horizontal rotor with herringbone-grooved gasdynamic rotors are briefly discussed, and results of rotor studies are presented. It is shown that the results of these studies can be generalized in the form of an expression relating the dimensionless reduced rotation frequency to the dimensionless reduced rotor mass. V.L.

A89-21820
OPTICALLY AIDED VISUAL INSPECTION OF AIRCRAFT STRUCTURE
D. HAGEMAIER, B. BATES, and D. CHRISTINA (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 46, Dec. 1988, p. 1696-1701, 1707.

An evaluation is made of the development status and capabilities of such visual inspection devices for aircraft structural, mechanical, and propulsion systems inspection as borescopes, endoscopes, and flexible borescopes. Typical of the applications to which these NDT devices can be put are the detection of torsion-bar bore-corrosion pitting, the cracking of a wing slat-drive mechanism's bell-crank, a spoiler-actuation mechanism's lube-hole cracks, wing rear spar doubler and web cracks under a trapezoidal

fitting, cracks on a rudder rib-flange, main landing gear truck-beam pitting corrosion, and cracks on a wing front-spar's lower cap. O.C.

A89-22286#
REDISTRIBUTION OF AN INLET TEMPERATURE DISTORTION IN AN AXIAL FLOW TURBINE STAGE
T. L. BUTLER, O. P. SHARMA (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT), H. D. JOSLYN, and R. P. DRING (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 64-71. Previously cited in issue 20, p. 2961, Accession no. A86-42658. refs

A89-22287#
EFFECTS OF INLET PRESSURE FLUCTUATIONS ON AXIAL FLOW COMPRESSORS
D. K. DAS (New York, State University, Utica) and A. TRIPPI (Cranfield Institute of Technology, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 72-81. Previously cited in issue 18, p. 2661, Accession no. A85-39619. refs

A89-22288#
FREESTREAM TURBULENCE EFFECT ON TURBINE AIRFOIL HEAT TRANSFER
R. D. ZERKLE and R. J. LOUNSBURY (General Electric Co., Cincinnati, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 82-88. Previously cited in issue 20, p. 3143, Accession no. A87-45297. refs

A89-22289#
ROTOR-WAKE INFLUENCE ON AXIAL-COMPRESSOR-STATOR BOUNDARY LAYERS
J. L. HANSEN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and T. H. OKIISHI (Iowa State University of Science and Technology, Ames) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 89-94. Research sponsored by USAF. Previously cited in issue 20, p. 3216, Accession no. A87-45178. refs

A89-22293#
BIDIRECTIONAL TAPERED ROLLER THRUST BEARING FOR GAS TURBINE ENGINES
R. LENGLADE (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), G. KREIDER, and R. PECH (Timken Co., Canton, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 116-121. Previously cited in issue 20, p. 3239, Accession no. A87-45243. refs
(Contract F33615-84-C-2409)

A89-22352#
PLANAR IMAGING OF JET MIXING IN CROSSFLOW
A. VRANOS and D. S. LISCINSKY (United Technologies Research Center, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1297, 1298.

A unique experiment has been developed for the study of jet mixing in crossflow. The scalar mixing of a round jet discharging normally into a ducted flow is studied through planar nephelometry. Simultaneous, multiple-point fluid concentration measurements are made for a variety of flow conditions in a simulated gas turbine combustor. The field measurements are in good agreement with the point-to-point measurements of other investigators. The potential for studying more practical, multijet configurations is evident. Author

A89-22362#
AEROELASTIC DIVERGENCE OF SWEPT-FORWARD COMPOSITE WINGS INCLUDING WARPING RESTRAINT EFFECT
L. LIBRESCU and A. A. KHDEIR (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 26, Nov. 1988, p. 1373-1377. refs

A powerful analytical approach to the divergence instability of laminated composite swept-forward wings is developed in the paper. The approach, based on the state space concept (used in conjunction with Jordan canonical form), enables one to solve exactly the equations governing the aeroelastic divergence of swept-forward composite wings, the warping restraint effect being incorporated into the analysis. The results obtained here emphasize the complex role played by the warping restraint effect in the divergence instability of swept-forward composite wings. Author

A89-22373#
THE DESIGN OF ROTARY REGENERATOR FOR GAS TURBINES
JUNG-YANG SAN (National Chunghsing University, Taichung, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 9, June 1988, p. 183-190. refs

A method based on the second law of thermodynamics is proposed for the design of rotary honeycomb type heat exchanger in gas turbines. The heat transfer in the fluid is assumed to be one-dimensional in the flow direction, and the lumped-heat-capacity analysis is applied to each solid element which only exchanges heat with its neighboring fluid element. The magnitude and relative importance of the thermal resistances in the directions parallel and perpendicular to the flow are demonstrated, and the effect of the B(i) on the effectiveness is investigated. The optimum Ntu and C(min)/C(r), corresponding to the maximum thermal efficiency, are obtained for an automobile gas turbine with the compression ratio equal to 4.0. A general procedure in the form of a flow chart is provided to evaluate the channel length and wheel rotational speed. Author

A89-22578*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SOURCES OF ERROR IN THE GRAPHICAL ANALYSIS OF CFD RESULTS
PIETER G. BUNING (NASA, Ames Research Center, Moffett Field, CA) Journal of Scientific Computing (ISSN 0885-7474), vol. 3, June 1988, p. 149-164. refs

Errors inherent to the graphic analysis of CFD solutions are discussed. Consideration is given to contouring, plotting of vector fields, particle tracing, and the computation of flow functions involving integration or differentiation. Many of the problems addressed are the direct result of knowing the function values only at grid points, not in the interior of the grid cells. K.K.

A89-22783
STABILITY OF WHIRL AND WHIP IN ROTOR/BEARING SYSTEMS
A. MUSZYNSKA (Bently Rotor Dynamics Research Corp., Minden, NV) Journal of Sound and Vibration (ISSN 0022-460X), vol. 127, Nov. 22, 1988, p. 49-64. refs

Experimental observations of rotor excited vibrations (known as oil whirl and oil whip) due to fluid dynamic forces generated in an oil-lubricated rotor/bearing are reported which reveal multiple regimes. A 4-dof rotor model is used to analyze the observations. Beyond the threshold of stability, the pure rotational motion of the shaft becomes unstable and the whirl regime becomes stable. With increasing rotational speed the whirl is shown to transform smoothly into whip. R.R.

A89-22797
THE PRINCIPLE OF GENERAL ENERGY CONSERVATION AND AN APPLICATION TO THE STABILITY ANALYSIS OF A ROTOR-BEARING SYSTEM
L. YU, Y.-B. XIE, J. ZHU, and D. QIU (Xian Jiaotong University, People's Republic of China) Journal of Sound and Vibration (ISSN 0022-460X), vol. 127, Dec. 8, 1988, p. 353-363. Research supported by the National Natural Science Foundation of China. refs

The concept of a complex energy and the principle of general energy conservation for a second-order mechanical system in free vibration are presented. As an application of this principle, the stability margin of a rotor system supported by sliding bearings is discussed, and the general energy ratio is taken as the index to

measure the stability margin of the system with unvaried parameters. Furthermore, the rate of change of the stability margin is adopted to describe the trend of the variation of the stability margin of system with small disturbances of parameters. Another important conclusion is that it is not always proper to estimate the stability margin of a system by its 'system damping'. Corresponding numerical examples are presented. Author

A89-22816#
LOCAL HEAT-TRANSFER CHARACTERISTICS OF GLAZE-ICE ACCRETIONS ON AN NACA 0012 AIRFOIL
M. R. PAIS, S. N. SINGH, and L. ZOU (Kentucky, University, Lexington) Journal of Aircraft (ISSN 0021-8669), vol. 25, Dec. 1988, p. 1136-1141. Research supported by USAF. refs

Laboratory-scale experiments were conducted in the subsonic wind-tunnel facility at the University of Kentucky. Experimental convective local heat-transfer coefficients were obtained for a simulated, full-scale, selected set of 0- and 5-min glaze like ice models on a NACA 0012 airfoil. A steady-state heat-flux method was employed. Local Nusselt numbers for a smooth NACA 0012 airfoil at angles of attack of 0, 2, 4, 6, and 8 deg, and on a 5-min smooth glaze-ice shape on the same airfoil at alpha = 4 deg were also obtained. For the 5-min model, the maximum Nusselt number occurs at the tip of the horn, where it is about 51 percent higher than the rest of the surface, and 25 percent higher for the same location on the 0-min model. A comparison with published results on a NACA 65, 2-016 airfoil is also presented. Author

A89-22848
EVALUATION OF STRESS INTENSITY FACTORS FOR CORNER CRACKED TURBINE DISCS UNDER ARBITRARY LOADING USING FINITE ELEMENT METHODS
R. BELL, J. KIRKHOPE (Carleton University, Ottawa, Canada), and I. A. PAGOTTO (GasTops, Ltd., Ottawa, Canada) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 32, no. 1, 1989, p. 65-79. refs
(Contract NSERC-A-3640)

This paper presents stress intensity factors, KI, obtained using three-dimensional finite elements for a range of depth and shape of corner crack around the bore in a rotating disk. One, two, three, and four equispaced radial cracks were considered, and the cracks had aspect ratios of b/a = 1, 2, and 4. The results are presented in the form of nondimensional magnification factors which can be superimposed to simulate any loading condition. This stress intensity information is valuable in the prediction of service lives of turbine disks. Author

A89-23012
STRUCTURAL SYSTEM RELIABILITY COMBINING THE CONSTRAINT OF DAMAGE TOLERANCE DESIGN
Y. S. FENG (Northwestern Polytechnical University, Xian, People's Republic of China) Computers and Structures (ISSN 0045-7949), vol. 30, no. 6, 1988, p. 1341-1346. refs

The present paper presents a methodology combining fracture mechanics with structural-system reliability theory in order to solve the panel-reliability analysis problem based on the requirement of damage-tolerant design. The panel under consideration is constituted by a plate and several stringers. Some illustrative examples are given. Based on the physical concepts and computational results some conclusions concerning the reliability and design are drawn. Author

A89-23302#
FINITE DIFFERENCE TECHNIQUES AND ROTOR BLADE AEROELASTIC PARTIAL DIFFERENTIAL EQUATIONS
S. HANAGUD, Y. K. YILLIKCI, and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 19 p. refs

A finite difference method for obtaining the transient and steady-state response solutions for rotor blades is presented. Rotor blade dynamical partial differential equations in time and space are solved using two-step finite difference schemes. Results are given for flap-lag motions and flap-lag torsion motion in forward flight. It is suggested that it is possible to combine the methods used in this study with computational fluid mechanics results to solve aeroelastic problems with accurate aerodynamics. R.B.

A89-23331#
EXPERT SYSTEMS AND QUALITY CONTROL
M. CHIQUILLO and M. CELOR (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 7 p.

An expert system application in the manufacture of helicopter parts is examined. The system models the knowledge of specialists on optimized integration of quality inspection plants into production process layouts. The computerization of the inspection phases integration is addressed. C.D.

A89-23332#
THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE ELASTIC AND INERTIAL PROPERTIES OF AN HELICOPTER BLADE
M. POUILLOT (Aerospatiale, Division Helicopteres, Marignane, France) and P. SAVEL (Aerospatiale, Le Bourget, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 11 p.

The validation of theoretical and experimental methods used to determine the elastic and inertial properties of helicopter blades is addressed. Parasitic effects that may alter measurements and the solutions adopted to improve the accuracy of results are examined. A method of measuring data analysis is described which involves solving a multidimensional calibration problem with confidence intervals where the various sources of error, such as the influence of noise on measurements or theoretical inadequacy, are considered. The test method used to determine the blade torsional properties is described. C.D.

A89-23341#
FLOW VISUALIZATION ON A HELICOPTER ROTOR IN HOVER USING ACENAPHTHENE
C.-H. ROHARDT (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 21 p. refs

The acenaphthene method is used for flow visualization of the boundary layer characteristics of a helicopter rotor blade under real conditions in hover flight. Laminar boundary layers are found on a large portion of the rotor blade surface. The laminar-turbulent transition location is determined and compared with results from a two-dimensional computer code, showing satisfactory agreement. R.B.

A89-23357#
HAMILTONIAN MECHANICS AS A POSSIBLE ALTERNATIVE FOR DERIVING AERO-ELASTIC EQUATIONS
TH. VAN HOLTEN (Stork Product Engineering, Amsterdam, Netherlands) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 11 p. refs

A method for deriving aeroelastic equations for complicated nonlinear problems is proposed whereby the generally time consuming procedure is simplified by introducing Hamilton's generalized momenta as variables. By adopting this approach, the problem can be solved by direct numerical computation without having to perform lengthy analytical differentiations that are required in Lagrange's procedure. The method is illustrated by an example taken from a design analysis of a large wind turbine. V.L.

A89-23580
VIBRATIONS OF A HORIZONTAL ROTOR IN ELASTIC SUPPORTS WITH CLEARANCES [KOLEBANIIA GORIZONTAL'NOGO ROTORA V UPRUGIKH OPORAKH S ZAZORAMI]
A. S. KEL'ZON and A. A. KOVAL' (Leningradskoe Vysshee Inzhenernoe Morskoe Uchilishche, Leningrad, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 303, no. 3, 1988, p. 570-573. In Russian.

The motion of a rotor with a horizontal rotation axis mounted in elastic supports with radial clearances is analyzed using a simplified model which treats the rotor as a point mass. Although the model is a significant simplification of a real rotor scheme, the approach proposed here allows the generalization to the case of a shaft with several supports, with the mass distributed along the length of the shaft. A horizontal rotor mounted in two supports with radial clearances is examined as an example. V.L.

A89-23682
USING ADAPTABILITY THEORY IN THE STRENGTH ANALYSIS OF GAS TURBINE DISKS [K VOPROSU OB ISPOL'ZOVANII TEORII PRISPOSOBLIAEMOSTI V RASCHETAKH NA PROCHNOST' DISKOV GAZOVYKH TURBIN]
A. R. BELIAKOV, L. B. GETSOV, V. K. DONDOSHANSKII, and IU. B. SHNEERSON Problemy Prochnosti (ISSN 0556-171X), Nov. 1988, p. 100-106. In Russian. refs

Various aspects of the use of adaptability theory for the strength analysis of gas turbine disks with stress concentrators operating under cyclic loading are examined. A method for determining the limiting values of the yield strength of the disks and a method for determining the safety factor from adaptability curves are described. Calculation results are presented for turbine disks tested to failure. V.L.

A89-23695
ANALYSIS OF A LAMINAR BOUNDARY LAYER ON A PLATE WITH ALLOWANCE FOR LIFT FORCES ACTING ON A DISPERSE IMPURITY [RASCHET LAMINARNOGO POGRANICHNOGO SLOIA NA PLASTINE S UCHETOM POD'EMNYKH SIL, DEISTVUIUSHCHIKH NA DISPERSNUIU PRIMES']
V. A. NAUMOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1988, p. 171-173. In Russian. refs

A gas-dispersion laminar boundary layer on a flat semiinfinite plate is analyzed by the finite difference method. It is found that the effect of lift forces acting on the disperse particles can be neglected only in the case of low Reynolds numbers (much less than 1) calculated from the incoming flow velocity and particle size. In the case where Re is approximately equal to 1 in the wall region near the leading edge, the transverse velocity of the disperse impurity is directed toward the plate, which leads to the deposition of the impurity. V.L.

A89-23813
FLOW DIAGNOSTICS WITH OPTICAL MEASUREMENT METHODS [STROEMUNGSDIAGNOSE DURCH OPTISCHE MESSVERFAHREN]
KARL-ALOYS BUETEFISCH and JUERGEN KOMPENHANS (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 28-34. In German.

Various ways of diagnosing flows using optical methods are described. The use of lasers to visualize flows is addressed, and the use of Doppler flash methods such as Particle Image Velocimetry to obtain a 'snapshot' of two-dimensional velocity fields is considered. The application of three-component laser-Doppler anemometers in large wind tunnels to make local velocity measurements is discussed. C.D.

A89-23815
THE MULTIAXIS VIBRATION SIMULATOR MAVIS - A NEW STRUCTURALLY DYNAMIC TEST BED [DER MEHRACHSENVIBRATIONSSIMULATOR MAVIS - EINE NEUE STRUKTURDYNAMISCHE TESTANLAGE]
ELMAR BREITBACH, HORST HUENERS, and JEAN-LUC REBIERE (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1988, p. 40-43. In German.

The need for a new, structurally dynamic test concept for air and space flight structures is discussed, and the multiaxis vibration simulator MAVIS is addressed as an answer to this need. The design of MAVIS is depicted and described. The application of MAVIS in air and space technology is examined. C.D.

A89-23853
ROTORDYNAMICS OF TURBOMACHINERY
JOHN M. VANCE (Texas A & M University, College Station) New York, Wiley-Interscience, 1988, 400 p. refs

The fundamental principles of rotordynamics analysis, design, and testing are examined in a general introduction intended for practicing engineers. Chapters are devoted to rotordynamics considerations in turbomachine design, torsional vibration analysis, critical speeds and response to imbalance, rotor balancing in turbomachinery, bearings and seals, rotordynamic instability, and measurement techniques and instrumentation. Diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A89-23870
28TH LANCHESTER MEMORIAL LECTURE - EXPERIMENTAL REAL-GAS HYPERSONICS
H. G. HORNUNG (California Institute of Technology, Pasadena) Aeronautical Journal (ISSN 0001-9240), vol. 92, Dec. 1988, p. 379-389. refs

It is possible to simulate a number of dissociative real-gas effects in the laboratory by means quite different from those of the perfect-gas Mach-Reynolds simulation, as presently demonstrated for two sets of results obtained in a free-piston shock tunnel experimental facility designed and built for this purpose. The results concern blunt body flows, which involve the phenomenon of dissociation quenching, and shock detachment from a wedge, which revealed a novel effect of reacting flows in which a thin subsonic layer exists after the shock, followed by a supersonic flow. O.C.

A89-23994
QUANTIFIED NONDESTRUCTIVE EVALUATION CAPABILITY - A MAJOR ELEMENT IN ENGINE STRUCTURAL INTEGRITY PROGRAMS
PAUL A. DOMAS (General Electric Co., Aircraft Engine Business Group, Evendale, OH) Materials Evaluation (ISSN 0025-5327), vol. 46, April 1988, p. 626-628, 630, 631, 635.

The Engine Structural Integrity Program (ENSIP), the military aircraft turbine engine design philosophy embodied in MIL-STD-1783, is briefly reviewed with emphasis on current trends and requirements related to nondestructive evaluation. In particular, it is noted that a more complete integration of NDE, design, material development, and manufacturing technology is required as the resolution limits of the most sophisticated NDE methods are approached. Such a unified design approach is critical for the successful application of ENSIP to advanced engines. V.L.

A89-24094
EHF MONOLITHIC PHASED ARRAYS - A STEPPING-STONE TO THE FUTURE
JOHN F. MCILVENNA and JOHN K. SCHINDLER (USAF, Rome Air Development Center, Hanscom AFB, MA) IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 731-735. refs

Current EHF monolithic phased-array technology is assessed; near-term technology needs are evaluated; and future developments in this field are projected. It is noted that such arrays are thought to be able to satisfy cost, real-estate, aerodynamic and radar-cross-section constraints. Test results on multielement monolithic subarrays operating at 20 and 44 GHz are examined. Finally, the connection between current state-of-the-art subarray technology and Smart Skins, the projected omnipotent phased array of the future, is discussed. I.E.

A89-24096
FIBER OPTIC LINKS FOR AIRBORNE EHF SATCOM TERMINAL APPLICATIONS
C. M. GEE, G. D. THURMOND, I. L. NEWBERG, H. W. YEN (Hughes Research Laboratories, Malibu, CA), D. LAFAW (USAF, Rome Air Development Center, Griffiss AFB, NY) et al. IN: MILCOM '88 - IEEE Military Communications Conference, San Diego, CA, Oct. 23-26, 1988, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 743-747. refs
(Contract F30602-86-C-0156)

Results of implementing fiber optics at 11 GHz in an experimental satellite communication EHF/SHF research terminal for airborne applications are reported. System measurements were made after a 100-m-long fiber-optic link replaced a 4-ft-long coaxial cable to enable the antenna to be positioned remotely from the terminal at X-band. Some of the advantages and disadvantages of fiber optics compared to coaxial and waveguide systems are discussed. It is concluded that the insertion of a 100-m-long fiber-optic link in a satellite communication terminal for airborne applications did not significantly degrade the SATCOM terminal performance. The link provides a lightweight, long-distance remote connection that is not practical at high frequencies with coaxial cable or waveguides. I.E.

A89-24142
SIMPLIFIED DESCRIPTION OF THE FIELD DISTRIBUTION IN FINLINES AND RIDGE WAVEGUIDES AND ITS APPLICATION TO THE ANALYSIS OF E-PLANE DISCONTINUITIES
RAAFAT R. MANSOUR, ROBERT S. K. TONG (COM DEV, Ltd., Cambridge, Canada), and ROBERT H. MACPHIE (Waterloo, University, Canada) (IEEE, International Microwave Symposium, 25th, New York, NY, May 25-27, 1988) IEEE Transactions on Microwave Theory and Techniques (ISSN 0018-9480), vol. 36, Dec. 1988, p. 1825-1832. refs

Using closed-form equations for the field distribution of the eigenmodes in ridge waveguides, a simplified analysis for ridge waveguide E-plane discontinuities is presented. The accuracy of the calculated results is checked by comparison with experimental results. Closed-form equations for the field distribution of the dominant hybrid mode in unilateral and bilateral finlines are also presented. The usefulness of these equations in calculating the characteristic impedance and in determining the plane of the circularly polarized magnetic field in unilateral finlines is demonstrated. I.E.

A89-24172
MEASURES OF TESTABILITY FOR AUTOMATIC DIAGNOSTIC SYSTEMS
NAEL A. E. ALY (California State University, Stanislaus) and ADEL A. ALY (Oklahoma, University, Norman) IEEE Transactions on Reliability (ISSN 0018-9529), vol. 37, Dec. 1988, p. 531-538. refs
(Contract N00019-83-C-0237)

Evaluation models of automatic diagnostic systems are investigated taking into consideration their imperfections such as failure to diagnose, incorrect isolation, false alarms, and inability to duplicate. Three measures of effectiveness are developed that enable the decision-maker to assess accurately the real capability of the diagnostic system and to evaluate and compare the performances of alternative automatic diagnostic systems based on their mean life-cycle cost. Analytic procedures for using these measures are developed, and an example is presented. It is concluded that the capability and performance of automatic diagnostic systems can be assessed using three measures of effectiveness: false removal, failure to diagnose, and false alarm correction. The three measures can be used to predict the mean life-cycle cost of automatic diagnostic systems, including the mean cost of imperfections of such systems. I.E.

A89-24309*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FURTHER GENERALIZATION OF AN EQUIVALENT PLATE REPRESENTATION FOR AIRCRAFT STRUCTURAL ANALYSIS
GARY L. GILES (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1, p. 93-103) Journal of Aircraft (ISSN 0021-8669), vol. 26, Jan. 1989, p. 07-74. Previously cited in issue 14, p. 2165, Accession no. A87-33562. refs

A89-24324#
BALL AND THE JACK
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 27, Jan. 1989, p. 44, 45.

One of the most efficient ways to control linear motion in aircraft actuators is through the use of a screw jack configuration in which the physical contact between the nut and screw is mediated by ball bearings. The screw forms the inner side of a hardened bearing track, called a 'race', while the nut forms the outer side; the ball bearings recirculate from one end of the nut to the other through return tubes. Rotary motion then converts to linear motion and force as the rotation of an axially-restrained nut moves a screw forward and backward. Efficiencies of 90-95 percent are obtainable, by comparison with the 30-35 percent of higher-friction conventional screw jacks. O.C.

A89-24872* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FRACTAL FEATURES OF SEA SURFACE MANIFESTED IN MICROWAVE REMOTE SENSING SIGNATURES
ROMAN E. GLAZMAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Wave propagation and scattering in varied media; Proceedings of the Meeting, Orlando, FL, Apr. 6-8, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 150-153. refs

The wave number spectrum of a well developed sea includes a broad range of wavenumbers (the equilibrium range) where the spectral density is governed by a power law, k exp p. In the approximation of a Gaussian surface, the exponent p is related to the Hausdorff dimension. For p less than 4 the Hausdorff dimension is greater than 2 and the surface is characterized by an increased number of steep and breaking wavelets and by an increased number of specular points at near vertical incidence. The former results in the so-called spike component in the total return at oblique incidence, whereas the latter leads to an increased backscatter at nadir and near-nadir angles. Theory for both cases is reviewed and implications for satellite scatterometer and altimeter measurements of surface winds are discussed. Author

N89-15266# University Coll. of Swansea (Wales). Reader in Materials Engineering.
METALLURGICAL MODELLING OF SUPERALLOY DISC ISOTHERMAL FORGINGS
R. W. EVANS *In* AGARD, Aerospace Materials Process Modelling 17 p Aug. 1988
Avail: NTIS HC A12/MF A01

The metallurgical structure of superalloy aeroengine disc forgings is a complex function of the forging operation parameters and the post forging heat treatment. It is often desirable to obtain certain specific structures in parts of the disc which are, for instance, resistant to crack propagation and this has traditionally been accomplished by means of a series of production trials. This expensive and time consuming procedure can be considerably shortened if the development of microstructure during the forging can be accurately modelled by a suitable computer code. Described here is such a model and its use in the design of isothermal forged components. The model discribed is a fully thermally coupled visco-plastic finite element algorithm. It treats nodal velocities as the basic unknowns and both the mesh geometry and the various metallurgical structural terms are updated by a single step Euler scheme. Facilities are available for ensuring that surface nodes follow die shapes after impingement, that flow is incompressible

and that suitable surface friction forces are applied. Throughout the whole forging process (which may involve the re-meshing of severely distorted elements), the metallurgical history of elements is retained so that the effects of subsequent heat treatments can be assessed. Author

N89-15345 Cranfield Inst. of Tech., Bedford (England).
THERMAL-HYDRAULIC DESIGNS OF FINNED HEAT-EXCHANGERS EXPERIENCING FREE OR FORCED CONVECTION Ph.D. Thesis
SHAILENDRA NAIK 1987 405 p
Avail: Univ. Microfilms Order No. BRDX81165

The thermal effectiveness of heat transfer equipment, in which the convective resistance constitutes the main barrier to heat flow, can be increased substantially by augmenting the heat-transfer surface with finned or extended surfaces. The design parameters involved in the thermal optimization are investigated for vertical rectangular fins protruding from a horizontal base when situated in an enclosure of infinite dimensions or an almost adiabatic duct of variable cross-sectional area. For a specified fin-array geometry, optimal fin separation, corresponding to the maximum steady-state rate of heat transfer from the heat exchanger, were deduced for the free and forced convective conditions. In addition local and average local and average heat transfers/fluid flows predicted from a three-dimensional forced convection numerical model were correlated to the experimental results. Dissert. Abstr.

N89-15349# Amtec Engineering, Inc., Bellevue, WA.
THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS FOR MOVING BODIES PAST FIXED STRUCTURES Final Report, 1 Jul. 1987 - 31 Jan. 1988
KELTON T. PEERY and SCOTT T. IMLAY 13 May 1988 44 p
(Contract DAAL03-87-C-0012)
(AD-A199982; ARO-25102.1-EG-SBI) Avail: NTIS HC A03/MF A01 CSCL 20D

A prototype computer program has been written to calculate three-dimensional viscous compressible flow past bodies in relative motion. The program solves the Navier-Stokes equations using multiple zones of mesh. During the Phase 1 research and development effort, routines were written to allow the meshes to move and to couple the solutions in adjacent zones along sliding boundaries. The importance of a well planned software structure was demonstrated. The code was applied to a turbine rotor/stator interaction problem. GRA

N89-15351*# CCS Associates, Bethel Park, PA.
HEAT PIPE COOLING FOR SCRAMJET ENGINES Final Report
CALVIN C. SILVERSTEIN Washington NASA Dec. 1986 160 p
(Contract NAS1-17908)
(NASA-CR-4036; NAS 1.26:4036; CCS-115) Avail: NTIS HC A08/MF A01 CSCL 20D

Liquid metal heat pipe cooling systems have been investigated for the combustor liner and engine inlet leading edges of scramjet engines for a missile application. The combustor liner is cooled by a lithium-TZM molybdenum annular heat pipe, which incorporates a separate lithium reservoir. Heat is initially absorbed by the sensible thermal capacity of the heat pipe and liner, and subsequently by the vaporization and discharge of lithium to the atmosphere. The combustor liner temperature is maintained at 3400 F or less during steady-state cruise. The engine inlet leading edge is fabricated as a sodium-superalloy heat pipe. Cooling is accomplished by radiation of heat from the aft surface of the leading edge to the atmosphere. The leading edge temperature is limited to 1700 F or less. It is concluded that heat pipe cooling is a viable method for limiting scramjet combustor liner and engine inlet temperatures to levels at which structural integrity is greatly enhanced. Author

N89-15367 Notre Dame Univ., IN.
TURBULENT BOUNDARY LAYER MODIFICATION BY STREAMLINED DEVICES Ph.D. Thesis
GLENN ALAN GEBERT 1988 226 p
Avail: Univ. Microfilms Order No. DA8813736

Unsteady aerodynamic theory and the rapid distortion approximation are used to study the modification of turbulent boundary layer large eddy structure by streamlined devices. In response to the fluctuations in the flow, the streamlined device will shed vorticity which induces a velocity field that modifies the turbulent boundary layer structure. The fluctuating velocity downstream of thin plate and airfoil shaped devices is calculated throughout the boundary layer for subsonic flows with two and three dimensional upstream harmonic disturbance. The results show that such devices most effectively suppress the fluctuating vertical velocity for a range of streamwise reduced frequencies. The intensity and the range of maximum suppression depends on the device geometry, loading, its distance to the wall, as well as the upstream disturbance conditions and the Mach number of the flow. The effect of the wall is shown, and it should be included in the analysis. The results also show that the modifications of the boundary layer are more significant if two devices are used, and if the devices have different chord lengths, and wider range of disturbances can be suppressed. Dissert. Abstr.

N89-15412 Texas A&M Univ., College Station.
ANALYSIS OF ECCENTRIC ANNULAR PRESSURE SEALS: A NEW SOLUTION PROCEDURE FOR DETERMINING REACTIVE FORCE AND ROTOR-DYNAMIC COEFFICIENTS Ph.D. Thesis
DUNG THANH NGUYEN 1988 146 p
Avail: Univ. Microfilms Order No. DA8815906

A new analysis procedure which solves for leakage, reactive force, and rotordynamic coefficients of eccentric annular fluid and gas pressure seals is presented. This analysis procedure is based on a perturbation technique and utilizes a turbulent bulk-flow model with Moody's friction factor. A set of zeroth-order equations and a set of first-order equations are derived from a perturbation of the flow variables. Solution to the zeroth-order equations yields leakage and ractive force; whereas solution to the first-order equations yields the rotordynamic coefficients. The solution for the zeroth-order equations is obtained by means of a new and efficient integration technique. Comparisons with existing experimental data indicate that predictions for liquid annular seals are very good. However, predictions for annular gas seals cannot be verified due to lack of test data. The results of this study also indicate that in systems of relatively low rotor stiffness, a rotor eccentricity below 0.40 in annular seals has essentially no effect on the vibration characteristics of the rotor. Dissert. Abstr.

N89-15437*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NONINTERACTIVE MACROSCOPIC RELIABILITY MODEL FOR CERAMIC MATRIX COMPOSITES WITH ORTHOTROPIC MATERIAL SYMMETRY
STEPHEN F. DUFFY (Cleveland State Univ., OH.) and JANE M. MANDERSCHEID 1989 9 p Prepared for presentation at the 34th International Gas Turbine and Aeroengine Congress and Exposition, Toronto, Ontario, 4-8 Jun. 1989; sponsored by ASME
(NASA-TM-101414; E-4512; NAS 1.15:101414) Avail: NTIS HC A02/MF A01 CSCL 20K

A macroscopic noninteractive reliability model for ceramic matrix composites is presented. The model is multiaxial and applicable to composites that can be characterized as orthotropic. Tensorial invariant theory is used to create an integrity basis with invariants that correspond to physical mechanisms related to fracture. This integrity basis is then used to construct a failure function per unit volume (or area) of material. It is assumed that the overall strength of the composite is governed by weakest link theory. This leads to a Weibull type model similar in nature to the principle of independent action (PIA) model for isotropic monolithic ceramics. An experimental program to obtain model parameters is briefly discussed. In addition, qualitative features of the model are illustrated by presenting reliability surfaces for various model parameters. Author

N89-15922# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Applied Mechanics.
PART 3: PARTICLE TRAJECTORIES IN AXIAL AND RADIAL TURBOMACHINES AND INLET SEPARATORS
AWATEF A. HAMED *In* Von Karman Institute for Fluid Dynamics, Particulate Flows and Blade Erosion 46 p 1988
Avail: NTIS HC A24/MF A01

The results of particle trajectory calculations in axial flow turbines and compressors are discussed. The effects of the particle characteristics in a single stage, then in multistage axial turbomachines are presented. The trajectories in radial inflow turbines and centrifugal compressors are considered. Particle dynamics in inlet separators are reviewed. ESA

N89-16072# Sandia National Labs., Albuquerque, NM.
PARACHUTE DRAWING STANDARDS CURRENTLY IN USE AT SANDIA NATIONAL LABORATORIES
K. L. RONQUILLO 1988 13 p Presented at the 10th AIAA Aerodynamic Decelerator Systems Technology Conference, Cocoa Beach, FL, 18 Apr. 1988
(Contract DE-AC04-76DP-00789)
(DE89-001365; SAND-88-2686; CONF-8804204-2) Avail: NTIS HC A03/MF A01

A need exists in the parachute industry for a standard method of defining and guiding the formation of textile drawings. Textile drawings have their own unique problems associated with their development. Unlike mechanical parts, textiles have no mass in cross section. Therefore, a cross-sectioned view has no hash marks. Hidden views are not usually incorporated in textile drawings as they are easily confused with stitch formations. Side views of textile parts are depicted using only one line to show thickness. This report will address these and other unique drawing problems associated with the development of parachute drawings and will offer, as a base, standards to be used when developing these drawings. DOE

N89-16117 Bath Univ. (England).
AN EXPERIMENTAL STUDY OF SONIC AND SUPERSONIC NOZZLES AND THEIR APPLICATION TO HIGH PRESSURE EJECTORS FOR AIRCRAFT ATTITUDE CONTROL Ph.D. Thesis
P. MILLER 1988 461 p
Avail: Univ. Microfilms Order No. BRDX82303

A study has been conducted of reaction controls for V/STOL aircraft using thrust augmenting ejector techniques. Rapid mixing nozzles have been developed for high pressure ejectors. Mass flow increases for sonic nozzles of up to 50 percent at x/D= 8 were recorded, compared with plain circular nozzles. Their use was found to improve the thrust performance of a simple ejector by 9 percent, and larger increases are believed possible. Results from an ejector performance prediction model were successfully compared with experimental data. The use of rapid mixing nozzles in a practical ejector design has been assessed. It is predicted that a maximum thrust increment of 20 percent could be achieved, compared with a simple fully expanded jet flow. Dissert. Abstr.

N89-16120# United Technologies Research Center, East Hartford, CT.
ADVANCES IN THE NUMERICAL ANALYSIS OF LINEARIZED UNSTEADY CASCADE FLOWS Interim Technical Report, Feb. 1985 - May 1988
JOSEPH M. VERDON and WILLIAM J. USAB, JR. Aug. 1988 74 p
(Contract F33615-84-C-2446)
(AD-A199211; UTRC-R88-957685-1; AFWAL-TR-88-2055) Avail: NTIS HC A04/MF A01 CSCL 13G

This report describes two new developments in the numerical analysis of linearized unsteady cascade flows, which have been motivated by the need for an accurate analytical procedure for predicting the onset of flutter in highly loaded compressor cascades. Numerical solutions have been determined using a two step procedure which first determined on a rectilinear-type cascade mesh to determine the unsteady flow over an extended blade-passage solution domain and then used polar-type local mesh to resolve the unsteady flow in high-gradient regions. In the present effort a composite solution procedure has been developed in which the cascade and local mesh equations are solved simultaneously. This allows the detail features of the flow within the local mesh region to impact the unsteady solution over the entire domain. In addition, a new shock-conforming local mesh has been introduced to permit a more accurate modeling of unsteady shock phenomena. Numerical results are presented to demonstrate the impact of the new composite solution procedure and the new local mesh on unsteady flow predictions. Results are also presented to illustrate the global unsteady aerodynamic response behavior of a compressor-type cascade operating at high subsonic inlet Mach numbers and at high mean incidences. GRA

N89-16172# Southwest Research Inst., San Antonio, TX.
GROWTH OF SMALL CRACKS IN AEROENGINE DISC MATERIALS Final Report, Aug. 1985 - Jan. 1988
S. J. HUDAK, JR., D. L. DAVIDSON, and K. S. CHAN Jun. 1988 249 p
(Contract F33615-85-C-5051)
(AD-A199842; AFWAL-TR-88-4090) Avail: NTIS HC A11/MF A01 CSCL 11F

Growth rate data for small fatigue cracks in fine grained and coarse grained Astroloy and in coarse grained Waspaloy were obtained at temperatures of 25 C, 200 C, and 600 C. Expressing the crack growth kinetics in terms of the linear elastic parameter resulted in small cracks growing faster than large cracks in all cases except that of the fine grained Astroloy at elevated temperature. This difference occurred even though the crystallographic nature of cracking in small cracks was shown to be the same as that in large cracks, based on metallographic, selected area electron channeling, and fractographic information. Furthermore, the fracture morphology of small and large cracks also exhibited the same dependence on temperature and applied stress level indicating that the crack propagation mechanism was the same in both cases. GRA

N89-16180# Naval Weapons Center, China Lake, CA.
STRUCTURAL RESPONSE OF FLAT PANELS TO HYDRAULIC RAM PRESSURE LOADING Final Report, Oct. 1984 - Oct. 1986
E. A. LUNDSTROM Feb. 1988 66 p
(AD-A200410; AD-E900797; NWC-TP-6770) Avail: NTIS HC A04/MF A01 CSCL 01C

Aircraft structural surfaces often serve as the walls of integral fuel cells. Projectiles penetrating the fuel generate intense pressure waves capable of producing catastrophic failure of the cell walls. This phenomenon, termed hydraulic ram, can lead to structural kill of the aircraft. Massive fuel loss, resulting from fuel cell failure, can also lead to aircraft kill by on-board fires or by fuel starvation. Drag forces acting to decelerate the projectile are the source of pressure waves that propagate into the fuel. A prominent characteristic of the fluid flow is a cavity that extends from the projectile back to the impact point.The theory for hydraulic ram effects in fuel tanks impacted by high-speed projectiles is extended. Experiments were performed with a simple, instrumented water tank and the test results compared with theoretical predictions. The comparison was good for hydraulic ram pressure in the water tank and for strain in the water tank walls. Predictions of catastrophic failure in the aluminum wall panels were in agreement with observations. The extended theory allows calculation for multiple impacts of projectiles that are supersonic with respect to the fluid. Energy-absorbing foam and air gaps at the fluid/structure interface are now included in the theory. Effects of dynamic cavitation at the fluid/structure interface on pressure loading are accounted for. GRA

N89-16193*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
A NOVEL APPROACH IN FORMULATION OF SPECIAL TRANSITON ELEMENTS: MESH INTERFACE ELEMENTS
Status Report
NESRIN SARIGUL Jan. 1989 67 p
(Contract NAG3-790; RF PROJ. 765939/719301)
(NASA-CR-184768; NAS 1.26:184768) Avail: NTIS HC A04/MF A01 CSCL 20K

The objective of this research is to develop more accurate and efficient advanced methods for solution of singular problems encountered in various branches of mechanics. The research program includes the formulation of new class elements called Mesh Interface Elements (MIE) to connect meshes of traditional elements either in three dimensions or in three and two dimensions. The finite element formulations are based on the boolean sum and blending operators. In today's advanced aircraft and space structure applications, steep temperature and/or stress gradients are commonly encountered. The analysis methods need to incorporate these steep gradients into the solution efficiently and accurately. Mesh Interface Elements are formulated and tested to account for the steep gradient effects. At present, the heat transfer and structural analysis problems are formulated from uncoupled theory point of view. The status report, first, summarizes the general formulation for heat transfer and structural analysis by including the newly introduced varying material properties at material nodal points of the elements concept. The the formulation of mesh interface elements is detailed. On the computational efficiency side, a hidden-symbolic computation concept developed by the author is given. Verfication examples are included from the heat transfer and structural analysis problems. The appendix includes listings of the computer modules developed for this purpose.
Author

N89-16196*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
CONTROL SURFACE SPANWISE PLACEMENT IN ACTIVE FLUTTER SUPPRESSION SYSTEMS
E. NISSIM and JOHN J. BURKEN Nov. 1988 19 p Prepared in cooperation with Technion - Israel Inst. of Tech., Haifa
(NASA-TP-2873; H-1492; NAS 1.60:2873) Avail: NTIS HC A03/MF A01 CSCL 20K

A method is developed that determines the placement of an active control surface for maximum effectiveness in suppressing flutter. No specific control law is required by this method which is based on the aerodynamic energy concept. It is argued that the spanwise placement of the active controls should coincide with the locations where maximum energy per unit span is fed into the system. The method enables one to determine the distribution, over the different surfaces of the aircraft, of the energy input into the system as a result of the unstable fluttering mode. The method is illustrated using three numerical examples. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

N89-15464# Lawrence Livermore National Lab., CA. Atmospheric and Geophysical Sciences Div.
A STUDY OF THE SENSITIVITY OF STRATOSPHERIC OZONE TO HYPERSONIC AIRCRAFT EMISSIONS
DONALD E. KINNISON, DONALD J. WUEBBLES, and HAROLD S. JOHNSTON Sep. 1988 6 p Presented at the 1st International Conference on Hypersonics Flight in the 21st Century, Grand Forks, IN, 20 Sep. 1988
(Contract W-7405-ENG-48; DE-AC03-76SF-00098)
(DE89-001240; UCRL-98314; CONF-8809167-1) Avail: NTIS HC A02/MF A01

There is new interest in the development of faster and more efficient aircraft for intercontinental passenger flights. Such aircraft would likely spend a high fraction of their flight time in the stratosphere. As a natural progression from studies that were done during the CIAP Program in the mid 1970s, this study investigates the sensitivity of stratospheric ozone to NO(sub x) and HO(sub x) emissions in conjunction with current understanding of atmospheric chemical and physical processes. The LLNL 1-D and 2-D chemical-radiative-transport models of the troposphere and stratosphere are used. Because of the significant uncertainties in possible future emissions, it is necessary that we examine the model's sensitivity to a wide range in magnitude, altitude, and latitude of assumed emissions. As well as examining different NO(sub x) and HO(sub x) emission levels, attempts are also made to examine the sensitivity of ozone to emissions under different background amounts of stratospheric chlorine (ClX). These studies lay the groundwork for future studies aimed at analyses of more realistic aircraft emission scenarios. DOE

N89-15485*# Electro Magnetic Applications, Inc., Lakewood, CO.
APPLICATION OF TRIGGERED LIGHTNING NUMERICAL MODELS TO THE F106B AND EXTENSION TO OTHER AIRCRAFT
POH H. NG, ROGER A. DALKE, JIM HOREMBALA, TERENCE RUDOLPH, and RODNEY A. PERALA Washington NASA Dec. 1988 239 p
(Contract NAS1-17748)
(NASA-CR-4207; NAS 1.26:4207; EMA-88-R-1) Avail: NTIS HC A11/MF A01 CSCL 04B

The goal of the F106B Thunderstorm Research Program is to characterize the lightning environment for aircraft in flight. This report describes the application of numerical electromagnetic models to this problem. Topics include: (1) Extensive application of linear triggered lightning to F106B data; (2) Electrostatic analysis of F106B field mill data; (3) Application of subgrid modeling to F106B nose region, including both static and nonlinear models; (4) Extension of F106B results to other aircraft of varying sizes and shapes; and (5) Application of nonlinear model to interaction of F106B with lightning leader-return stroke event. Author

N89-15486# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
PRELIMINARY RESULTS OF THE 1983 COORDINATED AIRCRAFT - DOPPLER WEATHER RADAR TURBULENCE EXPERIMENT, VOLUME 1
YEAN LEE, ALBERT R. PARADIS, and DIANE KLINGLE-WILSON 26 Jul. 1988 75 p
(Contract F19628-85-C-0002; DTFA01-80-Y-10546)
(AD-A197894; ATC-137-VOL-1; DOT/FAA/PM-86/11-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 04B

This report presents results of analyses of coordinated radar-aircraft data acquired from the 1983 experiment conducted at Hanscom AFB, Massachusetts. The objective of the experiment is to assess and validate the current NEXRAD algorithms for estimating aircraft turbulence from volume-scanned Doppler weather observations. Estimates of the turbulence severity index epsilon to the 1/3 power (a quantity used by NEXRAD) computed from radar and aircraft data are presented as a time series along each aircraft track. The radar point estimates of turbulence were averaged horizontally and vertically to yield layered Cartesian maps such as are intended for use by real time ATC controllers and pilots. The derived gust velocity (U sub de), also used to indicate the intensity of aircraft encountered turbulence, was computed so that comparisons could be made of the turbulence intensity scales inferred from values of epsilon and U sub de. These quantitative comparisons indicate that for the turbulence generally encountered during the flights, both radar and aircraft estimates of epsilon to the 1/3 power significantly overstate the severity of turbulence as reported by the aircraft pilot. The data analysis also shows that

radar-based estimates of epsilon to the 1/3 power, often significantly exceeded aircraft based estimates of epsilon to the 1/3 power. In contrast, the quantity U sub e underestimates the aircraft reported turbulence intensity on all the flights. The uncertainty as to operational useful thresholds for radar upsilon 1/3, aircraft upsilon 1/3 and U sub de is discussed as is the use of spectrum width as a turbulence indicator. GRA

N89-16228# Federal Aviation Administration, Washington, DC. Office of Environment and Energy.
A MICROCOMPUTER POLLUTION MODEL FOR CIVILIAN AIRPORTS AND AIR FORCE BASES. USER'S GUIDE, ISSUE 2
H. M. SEGAL Aug. 1988 46 p Sponsored in part by AFESC, Tyndall AFB, FL
(AD-A199795; FAA-EE-88-6; AFESC/ESL-TR-88-54) Avail: NTIS HC A03/MF A01 CSCL 24A

Over the past 8 years, the Federal Aviation Administration (FAA) and the United States Air Force (USAF) have developed a number of user-friendly emissions and dispersion models for air quality assessment purposes. The major result of this effort is the Emissions and Dispersion Modeling System (EDMS) which was completed in 1985 and released to the general public. Since that time, major modifications have been made in the EDMS system to enhance its usability and incorporate an integral dispersion model into its code. The approach of this guide is to provide hands-on instructions on how to use the model. The mechanism for doing this is an example problem which is introduced early in this document. Four short sections precede the example problem instructions. The first shows how the EDMS evolved from the earlier FAA and USAF mainframe models. The next three sections describe the hardware and software required to run Section 5 provides the hands-on instructions to produce: (1) an emissions inventory of all sources at an airport/airbase; and (2) an estimate of the concentrations produced by these sources at four airport locations. An inexperienced user should be able to process the example problem in less than 3 hours. GRA

N89-16243# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
LOW-ALTITUDE WIND SHEAR DETECTION WITH AIRPORT SURVEILLANCE RADARS: EVALUATION OF 1987 FIELD MEASUREMENTS
MARK E. WEBER and TERRI A. NOYES 31 Aug. 1988 102 p
(Contract DTFA01-80-Y-10546; F19628-85-C-0002)
(AD-A199189; ATC-159; DOT/FAA/PS-88/10) Avail: NTIS HC A06/MF A01 CSCL 04B

A field measurement program is being conducted to investigate the capabilities of airport surveillance radars (ASR) to detect low altitude wind shear (LAWS). This capability would require minor RF signal path modifications in existing ASRs and the addition of a signal processing channel to measure the radial velocity of precipitation wind tracers and automatically detect regions of hazardous velocity shear. A modified ASR-8 has been deployed in Huntsville, Alabama and is operated during periods of nearby thunderstorm activity. Data from approximately 30 wet (i.e., high radar reflectivity) microbursts during 1987 have been evaluated through comparison with simultaneous measurements from a collocated pencil beam weather radar. This report describes the 1987 approaches for LAWS detection with ASRs. Techniques are described for estimation of low altitude wind fields in the presence of interference such as ground clutter or weather aloft and for automatic detection of microburst wind shear from the resulting radial velocity fields. Evaluation of these techniques using case studies and statistical scoring of the automatic detection algorithm indicates that a suitably modified ASR could detect wet microbursts within 16 km of the radar with a detection probability in excess of 0.90 and a corresponding false alarm probability of less than 0.10. These favorable results indicate the need for careful consideration of implementation issues and the potential operational role of wind measurements from an ASR. GRA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A89-21147
THE DETERMINATION OF DEFECTIVENESS OF LINEAR STRUCTURAL DYNAMIC SYSTEMS
DECHAO ZHU and GUOQIN SHI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) (Chinese Society of Theoretical and Applied Mechanics, International Conference on Computational Engineering Mechanics, Beijing, People's Republic of China, June 21-25, 1987) Computers and Structures (ISSN 0045-7949), vol. 30, no. 4, 1988, p. 897-899. Sponsorship: National Science Foundation of China. refs
(Contract NSFC-1860376)

Formulas for determining the numbers of elementary divisors of various orders of a general matrix are developed and then applied to the structural-dynamic problem, to show whether the relevant matrix of the governing equations is defective or not. Illustrative examples are given, revealing that the present method is effective and easy to use. Author

A89-21248
A HIERARCHICAL KNOWLEDGE BASED SYSTEM FOR AIRPLANE CLASSIFICATION
DAN I. MOLDOVAN (Southern California, University, Los Angeles, CA) and CHUNG-I WU (Colorado, University, Denver) IEEE Transactions on Software Engineering (ISSN 0098-5589), vol. 14, Dec. 1988, p. 1829-1834. refs

Aircraft classification is used as an application domain to illustrate how hierarchical reasoning on large knowledge bases can be implemented. The knowledge base is organized as a two-dimensional hierarchy: one dimension corresponds to the levels of complexity often seen in computer vision, and the other dimension corresponds to the complexity of hypothesis used in reasoning process. Reasoning proceeds top-down, from more abstract levels with fewer details toward levels with more details. Whenever possible, with the help of domain knowledge, decision is taken at a higher level, which significantly reduces processing time. A software package called RuBICS (Rule-Based Image Classification System) is described, and some examples of aircraft classification are shown. I.E.

A89-22001#
SIMULATION STUDY ON ADJUSTMENT OF A GAS TURBINE UNIT
WEIDOU NI and SIQING LU (Tsinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Aug. 1988, p. 199-201. In Chinese, with abstract in English.

A controller for a gas turbine unit is designed and simulated with the linear quadratic optimal control method in modern control theory. Full and partial feedbacks are discussed. The results show that, if several main state variables are used, the control system has a successful close-loop performance. Author

A89-22508*# Purdue Univ., West Lafayette, IN.
COOPERATIVE SYNTHESIS OF CONTROL AND DISPLAY AUGMENTATION
SANJAY GARG and D. K. SCHMIDT (Purdue University, West Lafayette, IN) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 732-742) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Jan.-Feb. 1989, p. 54-61. Previously cited in issue 23, p. 3488, Accession no. A86-47484. refs
(Contract NAG2-228; NAG4-1)

A89-23313#
AN INTEGRATED APPROACH TO AIRBORNE SOFTWARE DEVELOPMENT
E. CAMBISE (Datamat Ingegneria di Sistemi S.p.A., Rome, Italy) and S. GAZZILLO (Agusta Sistemi S.p.A., Tradate, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 20 p. refs

The paper discusses the integrated approach used in the development and testing of the mission software of the Mission Avionic System (MAS) for the Italian Navy EH101 ASW/ASUV helicopter. The mission software implements a centralized interface for all the avionic subsystems and performs all the tactical computations. The approach addresses requirement definition and detailing; requirement analysis and software design; software development, testing, and computer hardware integration; and support to the mission avionic system ground integration. K.K.

A89-23314#
EH101 AVIONIC INTEGRATION PHILOSOPHY
E. GALLI (Agusta Sistemi S.p.A., Tradate, Italy) and E. CAMBISE (Datamat Ingegneria di Sistemi S.p.A., Rome, Italy) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 13 p.

This paper describes the philosophical approach used in the system integration and testing of the EH101 helicopter aircraft management system (AMS) and the mission avionics system (MAS), and discusses the steps followed during the integration and testing of the avionics system in terms of requirements, the hardware/software integration, and system integration. Particular attention is given to the tests of the software at the phases of host testing and target testing, the AMS rig (dedicated to the testing of the AMS software), the MAS rig (dedicated to the target evolution), and the hardware used for the overall integration. Block diagrams are included. I.S.

A89-23329#
AVIONICS SYSTEMS - DEVELOPMENT METHODOLOGY AND DATA PROCESSING TOOLS
M. SLISSA (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 7 p.

The role of avionics systems in meeting mission performance requirements is discussed. The objectives of a strict methodology applied to avionics system development are addressed, and the main development phases of an avionics system are described, with specific reference to the activities involved and the ensuing results. The relationship between avionics program participants is examined, and the nature of modifications made in avionics is summarized. The means of avionics system development in the Aerospatiale helicopter division are examined. C.D.

A89-23330#
MASTERING QUALITY OF AVIONICS SYSTEM'S SOFTWARE
A. REBOUL (Aerospatiale, Division Helicopteres, Marignane, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 5 p.

A specific development methodology for avionics systems software is being developed by the Helicopter division of Aerospatiale which takes the safety aspects of digital equipment into account. The quality assurance organization for system and software and the relations existing between the various departments involved with systems/software quality are discussed. The main activities involved and the way that system/software quality assurance actions are planned are described. C.D.

A89-23374#
AVIONIC DEVELOPMENT MEANS A COMPLETE INTEGRATED OPERATIONAL SOLUTION
J. P. QUEMARD (Electronique Serge Dassault, S.A., Saint-Cloud, France) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 16 p.

This paper discusses problems involved in the complete integration of aircraft avionics, including the implementation of precise and rigorous methodology, the availability of a compact hardware for a wide range of applications, and the development of software organized around high-order languages. Consideration is given to the characteristics of the integration methodology and hardware, with particular attention given to the MINERVE methodology (which constitutes a set of rules for the software quality checks), the on-board avionics hardware, and the central-unit hardware for the avionics system debugging and validation. It is shown that the use of a large number of hardware building blocks facilitates an easy system expansion and the reuse of software. Block diagrams are included. I.S.

A89-23573
MODEL-BASED VISION BY COOPERATIVE PROCESSING OF EVIDENCE AND HYPOTHESES USING CONFIGURATION SPACES
YOSHINORI KUNO, KATSUSHI IKEUCHI, and TAKEO KANADE (Carnegie-Mellon University, Pittsburgh, PA) IN: Digital and optical shape representation and pattern recognition; Proceedings of the Meeting, Orlando, FL, Apr. 4-6, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 444-453. Research sponsored by Analytic Sciences Corp. refs
(Contract ARPA ORDER 4976; F33615-84-K-1520)

A model-based object recognition method which combines a bottom-up evidence accumulation process and a top-down hypothesis verification process is presented. A point in a configuration space represents a configuration of an object. If a feature is found which matches a part of an object model, the configuration space is updated to reflect the possible configurations of the object. The application of the method to SAR image recognition is discussed. K.K.

A89-23656
INTEGRAL EQUATIONS IN THE LINEAR THEORY OF CONTACT PROBLEMS [OB INTEGRAL'NYKH URAVNENIIAKH LINEINOI TEORII KONTAKTNYKH ZADACH]
A. V. BITSADZE (AN SSSR, Matematicheskii Institut, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 303, no. 2, 1988, p. 265-270. In Russian. refs

The paper is concerned with integral equations of the first kind in which integral terms represent boundary values of the potential of a boundary layer of unknown density. As an example, attention is given to simple equations of this kind commonly encountered in elasticity theory and in finite-span wing theory. A method for solving such integral equations is presented which is based on the theory of holomorphic vectors with three independent variables. V.L.

A89-23979#
EXPANSION SERIES IN THE LAPLACE DOMAIN OF INTEGRAL FUNCTIONS OCCURRING IN THE LIFTING SURFACE THEORY FOR NONPLANAR WINGS
TETSUHIKO UEDEA (National Aerospace Laboratory, Chofu, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, Nov. 1988, p. 157-160. refs

A89-24493
RELIABLE FLIGHT CONTROL SYSTEMS - COMPONENTS PLACEMENT AND FEEDBACK SYNTHESIS
M. MARITON and P. BERTRAND (CNRS, Laboratoire des Signaux et Systemes, Gif-sur-Yvette, France) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 6. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 151-155. refs

For modern spacecraft and aircraft, reliable flight-control systems (FCS) must be designed to provide some fault tolerance. The mission has to be carried out in the presence of failures. Jump linear-quadratic systems are proposed as a suitable mathematical model, and it is shown how control laws can be built with automatic reconfiguration and failure anticipation. A global approach to the design of reliable FCS is outlined. It incorporates

into a single analytical framework the three basic steps of the design (component selection, component location and control-law synthesis) and provides a cost index that is sensitive to both reliability and performance issues. Author

A89-24582
A MOVING-AVERAGE METHOD FOR INPUT SATURATION PROBLEM IN ADAPTIVE CONTROL
T. NOGUCHI, K. KANAI (Defense Academy, Yokosuka, Japan), N. HORI, P. N. NIKIFORUK, and M. M. GUPTA (Saskatchewan, University, Saskatoon, Canada) IN: Automatic control; Proceedings of the Tenth Triennial World Congress of IFAC, Munich, Federal Republic of Germany, July 27-31, 1987. Volume 10. Oxford, England and Elmsford, NY, Pergamon Press, 1988, p. 203-208. refs

A method of designing an adaptive control system for plants which have a magnitude limitation on the control input is considered. When the reference output is of the step response type, an input filter is used to spread the control input over a period of sampling instants such that the plant input does not exceed the limit. An extended input filter which is capable of reducing its order to zero is described. Using the filter, an indirect adaptive controller is designed using an algebraic polynomial method. Its application to the adaptive flight control of a VTOL aircraft in hovering and translational modes is considered. Author

A89-24809
INTERNATIONAL SYMPOSIUM ON DOMAIN DECOMPOSITION METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS, 1ST, ECOLE NATIONALE DES PONTS ET CHAUSSEES, PARIS, FRANCE, JAN. 7-9, 1987, PROCEEDINGS
ROLAND GLOWINSKI, ED. (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France; Houston, University, TX), GENE H. GOLUB, ED. (Stanford University, CA), GERARD A. MEURANT, ED. (CEA, Centre d'Etudes de Limeil-Valenton, Villeneuve-Saint-George, France), and JACQUES PERIAUX, ED. (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud; Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France) Symposium organized by the Institut National de Recherche en Informatique et en Automatique; Sponsored by the Society for Industrial and Applied Mathematics, U.S. Navy, DRET, et al. Philadelphia, PA, SIAM, 1988, 441 p. For individual items see A89-24810 to A89-24824.

Theoretical and applications aspects of domain-decomposition methods (DDMs) are discussed in reviews and reports. Topics addressed include the Schwarz alternating method, a DDM for three-dimensional elliptical finite-element problems, DDM preconditioners for elliptic problems in two and three dimensions, iterative substructuring methods, mixed FEM/finite-difference approaches in subdomain methods, and DDM versus block preconditioning. Consideration is given to fully vectorized element-by-element preconditioners for nonlinear solid mechanics, iterative methods for substructured elasticity problems, a Schwarz DDM for incompressible flow problems, vortex subdomains, block-structured solutions for transonic flows, and DDMs for the simulation of transient problems in CFD. T.K.

N89-15672# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Antriebsintegration.
SOLUTION OF THE TWO-DIMENSIONAL EULER EQUATIONS BY A FINITE VOLUME DISCRETIZATION ON UNSTRUCTURED TRIANGULAR MESHES
ARNO RONZHEIMER Jul. 1988 82 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1135)
(DFVLR-FB-88-34; ISSN-0171-1342; ETN-89-93659) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 28 Deutsche marks

The solution of the two-dimensional Euler equations by finite volume discretization on unstructured triangular meshes is described. The essential of using unstructured meshes is the possibility to simulate flows around complex geometries, where the generation of structured body-fitted grids is much more expensive. The solution procedure is based on a two-dimensional cell vertex scheme for structured meshes. The components of the procedure were adapted to the requirements of unstructured triangular meshes. The accuracy of the procedure is shown by subsonic and transonic flows around airfoils. The effects of artificial dissipation are investigated and the influence of several acceleration techniques is discussed. ESA

N89-16287*# Rockwell International Corp., Lakewood, CA. Aircraft Operations.
AN ADA PROGRAMMING SUPPORT ENVIRONMENT
AL TYRRILL and A. DAVID CHAN *In* NASA, Lyndon B. Johnson Space Center, First International Conference on Ada (R) Programming Language Applications for the NASA Space Station, Volume 1 12 p 1986
Avail: NTIS HC A18/MF A01 CSCL 09B

The toolset of an Ada Programming Support Environment (APSE) being developed at North American Aircraft Operations (NAAO) of Rockwell International, is described. The APSE is resident on three different hosts and must support developments for the hosts and for embedded targets. Tools and developed software must be freely portable between the hosts. The toolset includes the usual editors, compilers, linkers, debuggers, configuration magnagers, and documentation tools. Generally, these are being supplied by the host computer vendors. Other tools, for example, pretty printer, cross referencer, compilation order tool, and management tools were obtained from public-domain sources, are implemented in Ada and are being ported to the hosts. Several tools being implemented in-house are of interest, these include an Ada Design Language processor based on compilable Ada. A Standalone Test Environment Generator facilitates test tool construction and partially automates unit level testing. A Code Auditor/Static Analyzer permits the Ada programs to be evaluated against measures of quality. An Ada Comment Box Generator partially automates generation of header comment boxes. Author

N89-16297*# Weizmann Inst. of Science, Rehovoth (Israel). Dept. of Applied Mathematics.
IMPLEMENTATION OF ADA PROTOCOLS ON MIL-STD-1553 B DATA BUS
SMIL RUHMAN and FLAVIA ROSEMBERG *In* NASA, Lyndon B. Johnson Space Center, First International Conference on Ada (R) Programming Language Applications for the NASA Space Station, Volume 1 2 p 1986
Avail: NTIS HC A18/MF A01 CSCL 09B

Standardization activity of data communication in avionic systems started in 1968 for the purpose of total system integration and the elimination of heavy wire bundles carrying signals between various subassemblies. The growing complexity of avionic systems is straining the capabilities of MIL-STD-1553 B (first issued in 1973), but a much greater challenge to it is posed by Ada, the standard language adopted for real-time, computer embedded-systems. Hardware implementation of Ada communication protocols in a contention/token bus or token ring network is proposed. However, during the transition period when the current command/response multiplex data bus is still flourishing and the development environment for distributed multi-computer Ada systems is as yet lacking, a temporary accomodation of the standard language with the standard bus could be very useful and even highly desirable. By concentrating all status informtion and decisions at the bus controller, it was found to be possible to construct an elegant and efficient harware impelementation of the Ada protocols at the bus interface. This solution is discussed. Author

N89-16330*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
TOWARDS A GENERAL OBJECT-ORIENTED SOFTWARE DEVELOPMENT METHODOLOGY
ED SEIDEWITZ and MIKE STARK *In* NASA, Lyndon B. Johnson

Space Center, First International Conference on Ada (R) Programming Language Applications for the NASA Space Station, Volume 2 15 p 1986
Avail: NTIS HC A22/MF A01 CSCL 09B

An object is an abstract software model of a problem domain entity. Objects are packages of both data and operations of that data (Goldberg 83, Booch 83). The Ada (tm) package construct is representative of this general notion of an object. Object-oriented design is the technique of using objects as the basic unit of modularity in systems design. The Software Engineering Laboratory at the Goddard Space Flight Center is currently involved in a pilot program to develop a flight dynamics simulator in Ada (approximately 40,000 statements) using object-oriented methods. Several authors have applied object-oriented concepts to Ada (e.g., Booch 83, Cherry 85). It was found that these methodologies are limited. As a result a more general approach was synthesized with allows a designer to apply powerful object-oriented principles to a wide range of applications and at all stages of design. An overview is provided of this approach. Further, how object-oriented design fits into the overall software life-cycle is considered. Author

N89-16343*# Integrated Systems, Inc., Palo Alto, CA.
RT—BUILD: AN EXPERT PROGRAMMER FOR IMPLEMENTING AND SIMULATING ADA REAL-TIME CONTROL SOFTWARE
LARRY L. LEHMAN, STEVE HOUTCHENS, MASSOUD NAVAB, and SUNIL C. SHAH *In* NASA, Lyndon B. Johnson Space Center, First International Conference on Ada (R) Programming Language Applications for the NASA Space Station, Volume 2 3 p 1986
Avail: NTIS HC A22/MF A01 CSCL 09B

The RT BUILD is an expert control system programmer that creates real-time Ada code from block-diagram descriptions of control systems. Since RT BUILD embodies substantial knowledge about the implementation of real-time control systems, it can perform many, if not most of the functions normally performed by human real-time programmers. Though much basic research was done in automatic programming, RT BUILD appears to be the first application of this research to an important problem in flight control system development. In particular, RT BUILD was designed to directly increase productivity and reliability for control implementations of large complex systems. Author

N89-16354*# Rockwell International Corp., Cedar Rapids, IA.
APPLYING ADA TO BEECH STARSHIP AVIONICS
DAVID W. FUNK *In* NASA, Lyndon B. Johnson Space Center, First International Conference on Ada (R) Programming Language Applications for the NASA Space Station, Volume 2 8 p 1986
Avail: NTIS HC A22/MF A01 CSCL 09B

As Ada solidified in its development, it became evident that it offered advantages for avionics systems because of it support for modern software engineering principles and real time applications. An Ada programming support environment was developed for two major avionics subsystems in the Beech Starship. The two subsystems include electronic flight instrument displays and the flight management computer system. Both of these systems use multiple Intel 80186 microprocessors. The flight management computer provides flight planning, navigation displays, primary flight display of checklists and other pilot advisory information. Together these systems represent nearly 80,000 lines of Ada source code and to date approximately 30 man years of effort. The Beech Starship avionics systems are in flight testing. Author

N89-16391# Institute for Defense Analyses, Alexandria, VA.
FIGHTER AIRCRAFT DESIGN SYSTEM USER'S MANUAL Final Report
JOSHUA A. SCHWARTZ Sep. 1988 117 p
(AD-A200453; AD-E501034; IDA-M-430; IDA/HQ-88-33145)
Avail: NTIS HC A06/MF A01 CSCL 01C

This Memorandum Report is a User's Manual for a set of four Lotus 1-2-3 spreadsheet models for tactical fixed-wing aircraft design and sensitivities. A sizing model utilizes input requirements such as take-off and landing distances, mission radius, and combat turn rate to determine the wing size, engine thrust, empty weight, and gross weight of the aircraft. Two other models investigate off-design range payload and maneuverability performance. The fourth model estimates the RDT and E, acquisition, and procurement costs. GRA

N89-16437*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
USER'S MANUAL FOR INTERACTIVE LINEAR: A FORTRAN PROGRAM TO DERIVE LINEAR AIRCRAFT MODELS
ROBERT F. ANTONIEWICZ, EUGENE L. DUKE, and BRIAN P. PATTERSON Sep. 1988 126 p
(NASA-TP-2835; H-1443; NAS 1.60:2835) Avail: NTIS HC A07/MF A01 CSCL 12B

An interactive FORTRAN program that provides the user with a powerful and flexible tool for the linearization of aircraft aerodynamic models is documented in this report. The program LINEAR numerically determines a linear system model using nonlinear equations of motion and a user-supplied linear or nonlinear aerodynamic model. The nonlinear equations of motion used are six-degree-of-freedom equations with stationary atmosphere and flat, nonrotating earth assumptions. The system model determined by LINEAR consists of matrices for both the state and observation equations. The program has been designed to allow easy selection and definition of the state, control, and observation variables to be used in a particular model. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A89-20966
THE INFLUENCE OF SURFACE ROUNDING ON TRAILING EDGE NOISE
M. S. HOWE (BBN Laboratories, Inc., Cambridge, MA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 126, Nov. 8, 1988, p. 503-523. refs

The sound produced by low Mach number turbulent flow over an asymmetrically rounded trailing edge of an airfoil is investigated. Results are given for angles of the trailing edge wedge of 90 deg and less. It is found that, for a given turbulence intensity, surface beveling has a significant effect on the radiation only at sufficiently high frequencies that the trailing edge may be regarded as a straight-sided wedge over distances of the order of the turbulence length scale. R.R.

A89-21490
EFFECT OF CONSTANT ACCELERATIONS AND TRANSLATIONAL VIBRATIONS ON THE DRIFTS OF A FREE GYROSCOPE WITH A NONCONTACT SUSPENSION [VLIIANIE POSTOIANNYKH USKORENII I POSTUPATEL'NYKH VIBRATSII NA UKHODY SVOBODNOGO GIROSKOPA S NEKONTAKTNYM PODVESOM]
R. V. LIN'KOV and IU. M. URMAN Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Sept.-Oct. 1988, p. 3-8. In Russian. refs

The effect of accelerations on the drifts of a quasi-spherical rotor is investigated for the case of the absence of any resonance relations between the vibration frequency and the rotation velocities of the free rigid body. It is assumed that the deviations of the rotor surface from the spherical shape are small and axially symmetric; the sources determining the suspension field are also assumed to be axially symmetric. A mathematical theory for the drifts of a free gyroscope under conditions of constant and variable accelerations is developed on the basis of equations of translational and rotational motion for a quasi-spherical rotor. V.L.

A89-22285*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECTS OF WIND-TUNNEL WALL ABSORPTION ON ACOUSTIC RADIATION OF PROPELLERS
KENNETH J. BAUMEISTER (NASA, Lewis Research Center, Cleveland, OH) and WALTER EVERSMAN (Missouri-Rolla, University, Rolla) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Jan.-Feb. 1989, p. 56-63. Previously cited in issue 05, p. 672, Accession no. A87-17991. refs

A89-22327* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF SIGNAL JITTER ON THE SPECTRUM OF ROTOR IMPULSIVE NOISE
THOMAS F. BROOKS (NASA, Langley Research Center, Hampton, VA) Vertica (ISSN 0360-5450), vol. 12, no. 3, 1988, p. 257-265. Previously announced in STAR as N87-25827.

The effect of randomness or jitter of the acoustic waveform on the spectrum of rotor impulsive noise is studied because of its importance for data interpretation. An acoustic waveform train is modeled representing rotor impulsive noise. The amplitude, shape, and period between occurrences of individual pulses are allowed to be randomized assuming normal probability distributions. Results, in terms of the standard deviations of the variable quantities, are given for the autospectrum as well as special processed spectra designed to separate harmonic and broadband rotor noise components. Consideration is given to the effect of accuracy in triggering or keying to a rotor one per revolution signal. An example is given showing the resultant spectral smearing at the high frequencies due to the pulse signal period variability. Author

A89-22785
AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PROPAGATION OF SOUND WAVES THROUGH A TURBULENT BOUNDARY LAYER
M. SALIKUDDIN, C. K. W. TAM, and R. H. BURRIN (Lockheed Aeronautical Systems Co., Marietta, GA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 127, Nov. 22, 1988, p. 91-121. Research supported by the Lockheed Independent Research and Development Program. refs

A theoretical model of the transmission of propfan noise through a turbulent boundary layer has been developed which takes into account the effect of refraction due to velocity and density gradients in the turbulent boundary layer. The effect of turbulence damping is incorporated in the model by adding eddy viscosity terms in the motion equations. The model is validated by comparison with experimental results obtained for a point sound source. R.R.

A89-22787
THE RAY THEORY OF SUPERSONIC PROPELLER ACOUSTICS
C. J. CHAPMAN (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 127, Nov. 22, 1988, p. 145-153. Research supported by the Royal Aircraft Establishment. refs

The wavefront surface produced by a supersonic propeller is constructed in the standard way as an envelope of expanding spheres. Focusing of rays is shown to occur, determined by the curvature of this surface and consequent variation of ray tube areas during propagation. Two important factors, the amount of sweep and the length of edge with supersonic normal component of velocity, are investigated analytically by means of a family of 'quadratically swept' edges; the length of the supersonic part may be varied from zero to infinity, to give different waveforms. A straight radial edge, which emerges as a special case, is further analyzed. These results are believed to be a helpful preliminary to applying sonic boom methods, such as those based on Whitham's weakly nonlinear theory or the transonic equation. Author

A89-23351#
MEASURED AND PREDICTED IMPULSIVE NOISE DIRECTIVITY CHARACTERISTICS
K. J. SCHULTZ and W. R. SPLETTSTOESSER (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 21 p. refs

Measured rotor blade surface pressure data were used as source input for a prediction code including all three terms of the Ffowcs-Williams/Hawkings equation. The prediction code was first applied to a well documented hover condition, and the predicted acoustic waveforms and spectra were found to be in good agreement with experimental data up to tip Mach numbers of about 0.92. Good agreement in waveform and directivity was also demonstrated for two forward flight high-speed noise conditions and for one descending flight condition with strong blade-vortex interaction. V.L.

A89-23359#
HELICOPTER MODEL NOISE TESTING AT DNW - STATUS AND PROSPECTS
J. C. A. VAN DITSHUIZEN (Duits-Nederlandse Windtunnel, Emmeloord, Netherlands) AAAF, European Rotorcraft Forum, 13th, Arles, France, Sept. 8-11, 1987, Paper. 29 p. refs

The paper describes several helicopter noise scaling and testing aspects, the dimensions and characteristics of the open jet configurations, and applied test set-ups. Measurement techniques such as a transversing microphone array for mapping noise directivities and a directional array for selecting the noise of rotary sources are described. The aeroacoustic testing capabilities of the DNW open jet configuration are illustrated on the basis of a collection of data samples. K.K.

A89-24884
AERONAUTICAL ACOUSTICS - MATHEMATICS APPLIED TO A MAJOR INDUSTRIAL PROBLEM
D. G. CRIGHTON (Cambridge University, England) IN: ICIAM '87; Proceedings of the First International Conference on Industrial and Applied Mathematics, Paris, France, June 29-July 3, 1987. Philadelphia, PA, Society for Industrial and Applied Mathematics, 1988, p. 75-89. refs

This paper gives a commentary on aeronautical acoustics as a scientific field, and on those features of it that make it a field worthy of attention by applied mathematicians. After an overview of the issues involved in the practical problem of aircraft noise, the acoustic analogy is outlined; typical scaling laws following from it are given; and recent progress in its detailed application to simple vortex flows is described. The paper also sketches some of the principal aspects of modern propeller-noise theory and emphasizes the vital role that can be played in the formulation of a scientifically based prediction scheme by asymptotic techniques allied to appropriate modeling of mechanisms. Author

N89-15684*# Duke Univ., Durham, NC. Dept. of Mechanical Engineering and Materials Science.
AIRCRAFT INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Progress Report, period ending Dec. 1988
DONALD B. BLISS, JAMES A. GOTTWALD, MARK B. GUSTAVESON, JAMES R. BURTON, III, and CRAIG CASTELLINO Jan. 1989 21 p
(Contract NAG1-722)
(NASA-CR-184668; NAS 1.26:184668) Avail: NTIS HC A03/MF A01 CSCL 20A

Existing interior noise reduction techniques for aircraft fuselages perform reasonably well at higher frequencies, but are inadequate at lower, particularly with respect to the low blade passage harmonics with high forcing levels found in propeller aircraft. A method is being studied which considers aircraft fuselages lines with panels alternately tuned to frequencies above and below the frequency to be attenuated. Adjacent panels would oscillate at equal amplitude, to give equal source strength, but with opposite phase. Provided these adjacent panels are acoustically compact, the resulting cancellation causes the interior acoustic modes to become cut off and therefore be non-propagating and evanescent. This interior noise reduction method, called Alternate Resonance

Tuning (ART), is currently being investigated both theoretically and experimentally. This new concept has potential application to reducing interior noise due to the propellers in advanced turboprop aircraft as well as for existing aircraft configurations. This program summarizes the work carried out at Duke University during the third semester of a contract supported by the Structural Acoustics Branch at NASA Langley Research Center. Author

N89-15685*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ACOUSTIC EVALUATION OF THE HELMHOLTZ RESONATOR TREATMENT IN THE NASA LEWIS 8- BY 6-FOOT SUPERSONIC WIND TUNNEL
LAURENCE J. HEIDELBERG and ELLIOT B. GORDON (Sverdrup Technology, Inc., Cleveland, OH.) Jan. 1989 12 p
(NASA-TM-101407; E-4147; NAS 1.15:101407) Avail: NTIS HC A03/MF A01 CSCL 20A

The acoustic consequences of sealing the Helmholtz resonators of the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel (8x6 SWT) were experimentally evaluated. This resonator sealing was proposed in order to avoid entrapment of hydrogen during tests of advanced hydrogen-fueled engines. The resonators were designed to absorb energy in the 4- to 20-Hz range; thus, this investigation is primarily concerned with infrasound. Limited internal and external noise measurements were made at tunnel Mach numbers ranging from 0.5 to 2.0. Although the resonators were part of the acoustic treatment installed because of a community noise problem their sealing did not seem to indicate a reoccurrence of the problem would result. Two factors were key to this conclusion: (1) A large bulk treatment muffler downstream of the resonators was able to make up for much of the attenuation originally provided by the resonators, and (2) there was no noise source in the tunnel test section. The previous community noise problem occurred when a large ramjet was tested in an open-loop tunnel configuration. If a propulsion system producing high noise levels at frequencies of less than 10 Hz were tested, the conclusion on community noise would have to be reevaluated. Author

N89-15686*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MEASURED FAR-FIELD FLIGHT NOISE OF A COUNTERROTATION TURBOPROP AT CRUISE CONDITIONS
RICHARD P. WOODWARD, IRVIN J. LOEFFLER, and JAMES H. DITTMAR Jan. 1989 20 p
(NASA-TM-101383; E-4437; NAS 1.15:101383) Avail: NTIS HC A03/MF A01 CSCL 20A

Modern high speed propeller (advanced turboprop) aircraft are expected to operate on 50 to 60 percent less fuel than the 1980 vintage turbofan fleet while at the same time matching the flight speed and performance of those aircraft. Counterrotation turboprop engines offer additional fuel savings by means of upstream propeller swirl recovery. This paper presents acoustic sideline results for a full-scale counterrotation turboprop engine at cruise conditions. The engine was installed on a Boeing 727 aircraft in place of the right-side turbofan engine. Acoustic data were taken from an instrumented Learjet chase plane. Sideline acoustic results are presented for 0.50 and 0.72 Mach cruise conditions. A scale model of the engine propeller was tested in a wind tunnel at 0.72 Mach cruise conditions. The model data were adjusted to flight acquisition conditions and were in general agreement with the flight results. Author

N89-15730# Sandia National Labs., Albuquerque, NM.
LIQUID CRYSTALS FOR SURFACE SHEAR STRESS VISUALIZATION ON WIND TURBINE AIRFOILS
D. C. REDA, R. W. SMITH, T. C. BRYANT, and L. L. SCHLUTER 1988 11 p Presented at the 18th National Conference of the American Wind Energy Association, Honolulu, HI, 19 Sep. 1988
(Contract DE-AC04-76DP-00789)
(DE88-017117; SAND-88-0541C; CONF-880916-1) Avail: NTIS HC A03/MF A01

Experiments were conducted on the Sandia 17-m vertical axis wind turbine to test the liquid-crystal/surface-shear-stress visualization technique in field environments. A Sandia natural-laminar-flow airfoil served as the test surface. Initial feasibility experiments were conducted under high-tip-speed-ratio, high-Reynolds-number conditions, which resulted in low angle-of-attack, quasi-steady flow fields. Data acquisition was accomplished with a tower-mounted movie camera and 35 mm color film. Liquid crystal coatings sensitive only to surface shear stress, and insensitive to temperature changes for temperatures below 50 C, were utilized. Observations of coating color changes showed the liquid crystal technique capable of visualizing surface shear stress distributions, including (by contrast) regions of separated flow, under field-test conditions. DOE

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A89-20978
THE PROSPECTS FOR ADVANCED POLYMER-, METAL- AND CERAMIC-MATRIX COMPOSITES
THOMAS ABRAHAM, RICHARD W. BRYANT, and PETER J. MOONEY Journal of Metals (ISSN 0148-6608), vol. 40, Nov. 1988, p. 46-48.

A technological development status and a comparative economic competitiveness evaluation are presented for polymer-, metal-, and ceramic-matrix composites. Although polymeric composites have a much longer development history than the two other types, metal-matrix composites (MMCs) are noted to have certain exclusive niches to fill; it is anticipated, for instance, that future generations of advanced aircraft will have polymer-matrix skins, carbon/carbon high-temperature propulsion components, and MMCs virtually everywhere else in the primary structure and lower-temperature propulsion system elements. Ceramic-matrix composite costs are currently too high for extensive exploitation, although costs are expected to moderate with expanding production in specialized high-performance applications. O.C.

A89-24702
CONFLICT OF LAWS IN AIR CRASH CASES - REMARKS FROM A EUROPEAN'S PERSPECTIVE
MICHAEL BOGDAN (Lund, Universitet, Sweden) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Winter 1988, p. 303-348. refs

Private international law relating to air crash cases is considered, comparing the treatment of such cases in the U.S. and in Europe. The Warsaw Convention amendments of 1955 and the EEC Convention on Jurisdiction and the Enforcement of Judgments in Civil and Commercial Matters of 1968 are examined. Conflict rules on tortious liability in the U.S. and in Europe and contractual liability of the carrier are discussed. Conclusions are made concerning the problem of which nation should determine liability in international air crash cases. R.B.

A89-24703
THE DEFENSE OF AVIATION MECHANICS AND REPAIR FACILITIES FROM ENFORCEMENT ACTIONS OF THE FEDERAL AVIATION ADMINISTRATION
L. RONALD JORGENSEN Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Winter 1988, p. 349-437. refs

The actions that the FAA may take against individual aviation mechanics and air maintenance facilities in order to enforce the Federal Aviation Regulations (FARs) and the issues and procedures that an attorney should know to represent the mechanics or repair facilities in this situation are examined. The FAA certifications which a mechanic or maintenance facility needs in order to perform

maintenance on the U.S. civilian air fleet are described. The maintenance responsibilities and standards articulated in the FARs and in decisions of the National Transportation Safety Board (NTSB) are presented. The procedures of a case before the NTSB and the relationship between the FAA, the NTSB, and the FARs are examined. R.B.

A89-24704
DEFECTIVE MILITARY AIRCRAFT AND THE GOVERNMENT CONTRACTOR DEFENSE - THE CONSTITUTIONAL DIFFICULTIES THAT ARISE EVEN AFTER BOYLE V. UNITED TECHNOLOGIES CORP
G. NELSON SMITH, III Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Winter 1988, p. 439-498. refs

The historical development of the government contractor defense and the constitutional and policy ramifications behind the defense are discussed, concentrating on the defense as it relates to defective military aircraft. The government contractor defense shields a manufacturer from liability when the contractor performs work in accordance with government specifications, absent any willfully tortious conduct by the contractor. Several cases dealing with liability in the case of defective military aircraft are reviewed. The policy difficulties of the government contractor defense which existed prior to the Supreme Court decision in Boyle v. United Technologies Corp. (1988) and the implications of the case are examined. R.B.

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GENERAL

A89-21796#
AEROSPACE '88
LARRY A. DIEHL, DELMA C. FREEMAN, MARK HENLEY, NANCY GIDDINGS, LUKE FRANSCINI, III et al. Aerospace America (ISSN 0740-722X), vol. 26, Dec. 1988, p. 12-16, 18-22, 24-26 (45 ft.).

The year 1988's most significant events in the various fields of the aerospace industry in the U.S. are discussed. Attention is given to aeroacoustics, aerodynamic decelerators, aerospace maintenance, aerospace power, airbreathing propulsion, air transportation, aircraft design, aircraft operations, astrodynamics, flight mechanics, C3I, CAD/CAM, digital avionics, economics, electric propulsion, flight simulation, general aviation, interactive computer graphics, LTA, liquid rocket propulsion, materials, missiles, lasers, propellants, sensors, software, space operations and support, space transportation, structural dynamics, support systems, thermophysics, and V/STOL. O.C.

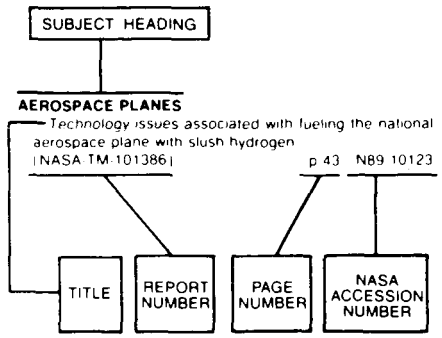
A89-24321#
AEROSPACE GLASNOST
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 27, Jan. 1989, p. 20-23, 40.

An account is given of the indications obtained to date concerning the design features and capabilities of the Soviet Union's space shuttle-type vehicle, 'Buran', as well as the Energiya heavy-payload launcher (which makes Mars-orbital missions possible), and the MiG-29 'Fulcrum' fighter aircraft displayed at the 1988 Farnborough air show. The MiG-29 has been judged by Western experts to be a thoroughly contemporary aircraft, rather than yet another stereotypically backward, excessively simple design. Plans have been made public for a Tupolev hypersonic aircraft design employing a turbojet/scramjet shared-inlet propulsion system. O.C.

N89-15886*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH AND TECHNOLOGY 1988 Annual Report
Dec. 1988 205 p Original contains color illustrations (NASA-TM-4078; L-16518; NAS 1.15:4078) Avail: NTIS HC A10/MF A01 CSCL 05D

The mission of the NASA Langley Research Center is to increase the knowledge and capability of the United States in a full range of aeronautics disciplines and in selected space disciplines. The mission will be accomplished by performing innovative research relevant to national needs and Agency goals, transferring technology to users in a timely manner, and providing development support to other U.S. Government agencies, industry, and other NASA Centers. This report contains highlights of the major accomplishments and applications made during the past year. The highlights illustrate both the broad range of the research and technology activities at NASA Langley and the contributions of this work toward maintaining U.S. leadership in aeronautics and space research. Author

Typical Subject Index Listing



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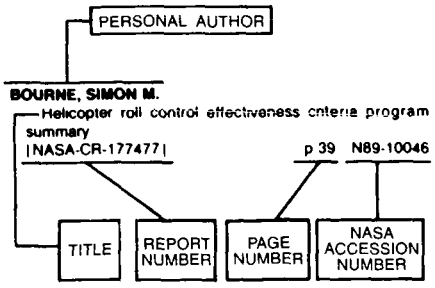

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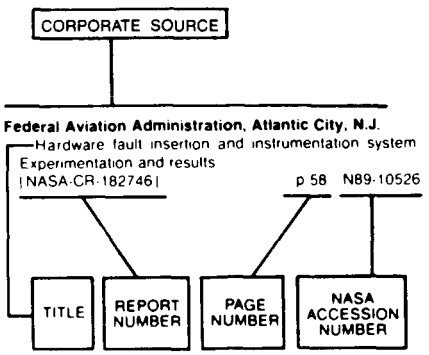

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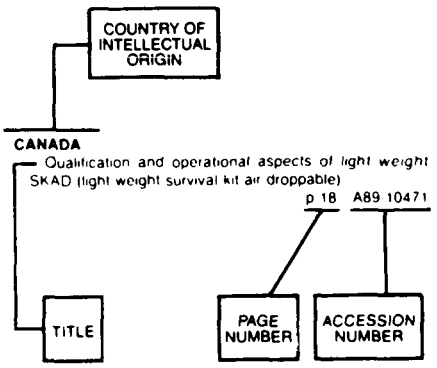

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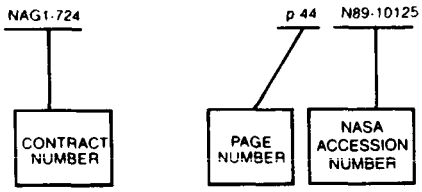

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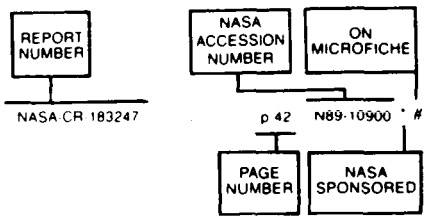

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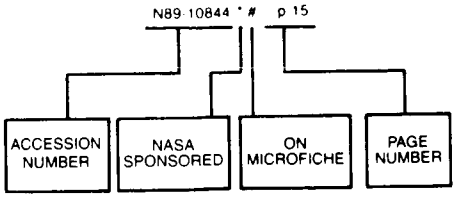

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